

Variability and Correlation in
Raw and Clean Coal: Measurement and Analysis

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VARIABILITY AND CORRELATION IN RAW AND CLEAN COAL:
MEASUREMENT AND ANALYSIS

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16. ABSTRACT The report gives results of the evaluation of coal samples, collected at 1/2- or 1-hour intervals from the inlet to, and outlet from, two coal preparation plants. (The ability of a coal to comply with an emission regulation depends on the statistical characteristics of the coal sulfur content and heat content and the requirements of the regulation. Previous studies of the ability of coal to comply with emission regulations have been hampered by inadequacies in the coal data sets which can be used to statistically characterize the variations in coal properties.) The samples were analyzed for total sulfur, pyrite sulfur, heating value, ash content, and moisture. Values for organic sulfur and SO ₂ emissions (lb SO ₂ /million Btu) were calculated. Data were evaluated statistically to determine the mean value, variance, relative standard deviation (standard deviation divided by mean), correlation structure, and skewness. Coal cleaning at the plants reduced the mean SO ₂ emission parameter by about 23 and 63 percent, respectively. The relative standard deviation (RSD) of the SO ₂ emissions were reduced by 26 and 44 percent, respectively. Differences in the reductions in mean and RSD values between plants resulted primarily from differences in raw coal properties. Model results show the importance of considering the effects of auto-correlations when estimating the potential for exceedance with raw or clean coal.		
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ABSTRACT

The ability of a coal to comply with an emission regulation depends on the statistical characteristics of the coal sulfur content and heat content and the requirements of the regulation. Previous studies on the ability of coal to comply with emission regulations have been hampered by inadequacies in the coal data sets which can be used to statistically characterize the variations in coal properties. In this project coal samples were collected and analyzed at two coal preparation plants, the R&F Coal Company plant and a Republic Steel Corporation plant. The resultant coal data sets were evaluated to determine the statistical properties of both the feed and product coals.

Each of the preparation plants had an automatic sampler which collected samples from conveyor belts at the plant inlet and outlet. Samples were collected at either 1/2 hour or 1 hour intervals. The R&F plant cleaned blends of surface mine coal from the Ohio No. 8, 9 and 11 coal seams. The Republic plant cleaned deep mined coal from a single seam, the lower Kittanning in West Virginia.

Coal samples from the plants were analyzed for total sulfur, pyrite sulfur, heating value, ash content and moisture. Values for the organic sulfur and SO_2 emission parameter ($\text{lb SO}_2/10^6 \text{ Btu}$) were calculated with ASTM or equivalent procedures.

The sample data were evaluated by statistical techniques to determine the: mean value, variance, relative standard deviation (standard deviation $\div$ mean), correlation structure and skewness. The correlation structure was evaluated by time series and geostatistic techniques. The time series techniques proved to be the most useful.

The coal cleaning processes at the R&F and Republic plants reduced the mean SO₂ emission parameter by approximately 23 and 63 percent respectively. The relative standard deviation (RSD) of the SO₂ emission parameters were reduced by 26 and 44 percent respectively. Differences in the reductions in mean and RSD values between plants resulted primarily from differences in the raw coal properties.

For much of the data acquired in this study, strong autocorrelation was indicated. The 30-minute increment data from the R&F plant were more highly autocorrelated than composite data collected over longer time intervals. The data from the Republic plant exhibited weaker autocorrelation than the R&F data. However, the results from both plants confirm that serial correlation of coal data does exist over short time intervals.

Time-series models were used to generate data sets much longer than the empirical (measured) data sets. These models are probabilistic and many different time series, equally likely, may be generated. Each time series for any given model is based upon the same mean, same variance, and same correlation structure.

The average number of emission violations produced by a power plant burning the R&F coal (either raw or cleaned) were estimated from a time series model for raw coal and a time series model for clean coal. For an emission limit 2.5 standard deviations greater than the mean, and for a 24-hour averaging time, the time series models predicted 12 violations per year for raw coal and 49 to clean coal. These violation frequencies are much greater than the frequency of 2 violations per year predicted from (erroneous) assumption of serially-independent coal data. These model results show the importance of considering the effects of autocorrelations when estimating the potential for emission limit exceedance with raw or cleaned coal.

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CONVERSION TABLE

1 Btu = 1054.8 joules

1 lb SO₂/10⁶ Btu = 433 ng SO₂/J

1 lb = 0.454 kg

1 in. = 2.54 cm

1 ton = 0.907 kkg

MESH SIZES

<u>Mesh No.</u>	<u>Inches</u>	<u>Millimeters</u>
8	0.094	2.38
28	0.023	0.59
48	0.0117	0.297
100	0.0059	0.149
200	0.0029	0.074

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SECTION 1.0

INTRODUCTION

Historically, estimating coal variability has been done with Gaussian statistics that assume independently varying coal parameters. Accordingly, in determining emission limits for coal-fired boilers, a histogram of coal data that ignores the time sequence of data is constructed. The histogram is then evaluated to find a distribution curve that is used to determine the mean coal sulfur value believed to ensure compliance with the specified emission limit. Studies now indicate that this method is inappropriate for the handling of coal data.

PRIOR STUDY OF SULFUR VARIABILITY DATA ASSOCIATED WITH COAL CLEANING PROCESSES

To date, the study of sulfur variability in coal prior to and following coal cleaning has been limited to the analysis of available production data for 53 coal-source/cleaning plant combinations⁽¹⁾. Data distributions for coal were compared to common distributions found for data sets whose points are independent of each other. The coal data sets did not fit these distributions. Moreover, tests for autocorrelation of the data points within data sets gave positive results in 16 of 48 data sets (at the 95 percent confidence level). There was little doubt, therefore, that much of these coal data were serially correlated, verifying expectations based upon geology and engineering rationale. The data were insufficient, however, to determine the correlation structure.

Limitations of Prior Studies

The prior Versar study, as well as several others, was based solely upon existing coal production data. Except for the few sets of paired feed and product data, such studies were hampered because the data sets did not

form logically consistent or homogeneous populations sufficient for rigorous statistical analysis. Indeed, much of the reported data was mixed with respect to mining method, cleaning method, sampling frequency and procedure, methods of compositing or averaging, definition of a "lot" of coal and the nominal lot size, and the analytical laboratory precision. The data sets comprised coals from different regions, seams, and mines, with inherent geological and engineering differences. Furthermore, the data sets were not necessarily representative of their respective regions or seams.

ASTM sampling and analytical protocols are widely followed by coal producers for determining the characteristics of product coal. However, little is known about the data for raw coal that is fed to coal cleaning plants, except that rigorous ASTM coal sampling protocols are not always followed. Any conclusions drawn about raw coal variability must be tempered by this data inadequacy.

Prior studies have also been hampered by the commercial practice of compositing samples and reporting data for relatively large quantities of coal. The relative paucity of data for short time increments (i.e., small coal quantities) has made it difficult to observe and analyze the components of coal variability.

Finally, the statistical analysis of available coal production data has been accomplished without a systematic independent measure of the actual sampling and analytical errors. In almost no instance of commercially reported data do the results of replicate determinations accompany the data. Without this independently determined measurement error, the components of the observed variance cannot be resolved with confidence. Moreover, there is no assurance that the measurement errors reported by multiple producers are mutually consistent, despite the wide acceptance of the ASTM protocols.

Because of these inherent comparability problems in studying available data that was originally acquired for quite different objectives, the prior studies led to only a rough picture of coal sulfur variability. The present study, featuring intensive sampling and analysis at selected coal cleaning plants, was designed to overcome the data deficiencies of prior studies.

OBJECTIVES OF THE PRESENT STUDY

This program was conducted as a controlled experimental study to accurately collect and analyze representative samples of raw and clean coal. The study used the same sampling procedures, sample preparation procedures, and laboratory analysis methods for both raw and clean coal samples, to measure correlation and variability in the coal sources tested and the attenuation of sulfur variability in coal preparation plants. Representative composite samples of varying size were tested to investigate the effect of different lot sizes.

The study had the following major objectives:

1. To measure and evaluate the reduction of variability of sulfur and heating value of raw versus clean coal by collecting and analyzing samples of raw and clean coal at two commercial plants.
2. To measure and quantify the observed variance of sulfur, heating value, and ash associated with the day-to-day changes in raw and clean coal and the uncertainty associated with sampling, sample preparation, compositing and analysis of raw and clean coal, i.e., uncertainty.
3. To evaluate the relationship between serial correlation and variability by determining whether the measured parameters in sequential coal samples are random and, if they are not, to separate the variability of the parameters into correlated and random components.
4. To determine the relationship between lot size and variability.

GENERAL CHARACTERISTICS OF COAL DATA

Because of the nature of coal formation, there is a certain structure (as opposed to complete randomness) in the properties of a coal deposit. Superimposed on this structure is a certain amount of randomness. Thus if samples are taken from a certain deposit, the statistical treatment of these data must recognize both correlated and random characteristics of the samples.

Further, sulfur dioxide released from coal combustion is a time-dependent phenomenon -- a sequence of emissions over successive time increments. The emission values in the sequence will depend upon the coal and the manner in which it is mined, prepared, transported, and fired in the boiler. It will also depend upon the use of air pollution control devices such as flue gas desulfurization units. Mining operations transform the spatial characteristics of coal into a time sequence of varying coal properties. Alternative mining approaches or schemes within the same deposit provide different time sequences of potential sulfur emissions. These sequences are subsequently modified by coal preparation, coal transportation, coal blending and sulfur emission control operations. One cannot assume, moreover, that the sequence for one coal data set is applicable to other coals.

Coal fired utility plants burn either raw (unwashed) coal, clean (washed) coal, or a blend of the two. Variability in sulfur content of these coals can produce variability in the level of emissions from the utility stack. To better estimate the variability in raw and clean coal, it is important to measure the statistical variance associated with the components of the variability in coal. These components of variability in coal relate to (1) variability within any one source of coal, (2) variability among the sources of coal being studied, (3) variability associated with sample collection and laboratory analysis, and (4) variability with different size lots of coal.

The autocorrelation properties of coal data are important and must also be evaluated. If they are ignored, then one may develop incorrect statistical models that lead to errors in decisions about the ability of coal to comply with SO₂ emissions regulations.

IMPORTANT STATISTICAL PROPERTIES

Three statistical measures are important in evaluating coal sulfur data:

- The mean value
- The variance, a measure of the data spread
- The autocovariance or autocorrelation, the statistical relationship of data points to other data points in the same time (or space) series

The mean value $\bar{x}$ is simply the sum of all values divided by the number of data points:

$$\bar{x} = \frac{1}{N} \sum_{t=1}^N x_t$$

where x_t is the value of x at time t , and N is the total number of data points. The variance is a measure of the data scatter about the mean value $\bar{x}$. In mathematical terms the variance is estimated by the expression:

$$s^2 = c_0 \sum_{t=1}^N (x_t - \bar{x})^2$$

where $c_0 = \frac{1}{N}$ or $\frac{1}{N-1}$ depending upon the application.

Visualizing $(x_t - \bar{x})^2$ as the square of the distance between the data point and the mean, one sees that the variance is the sum of the squared distances for each point in the data set multiplied by an appropriate constant. The value of S is an estimate of the standard deviation.

If values in a sequence of data points are dependent on previous values, then they are correlated with each other and are said to be autocorrelated. A measure of this dependence is the autocovariance:

$$\hat{\gamma}_k = c_k \sum_{t=1}^{N-k} (x_t - \bar{x})(x_{t+k} - \bar{x})^*$$

where $c_k = 1/N$, $1/(N-k)$ or $1/(N-k-1)$, depending upon the application of $k = 1, 2, 3, \dots$ are time or space lags measured from point t . An estimate

* applies only to stationary time sequences.

for the autocorrelation is $\hat{\gamma}_k / \hat{S}^2$. It is a normalized form of the autocovariance.

The usefulness of the autocovariance or autocorrelation is in forecasting future data from past data. Small autocorrelations may indicate that the correlations between past and present values are small and so past data provide little useful information in predicting future events. If the autocorrelation is large, it is essential to determine the time dependent effect of events through modeling in order to predict future trends. Once these trends have been forecast the variance can be used to provide an estimated measure of their accuracy.

SECTION 2.0

CONCLUSIONS

The results of this study are developed from data obtained at three sources:

- A physical coal cleaning facility at Homer City, Pennsylvania, where Versar tested sampling and analytical procedures to evaluate the uncertainty introduced by these methods in the data.
- An R&F Coal Company preparation plant, where Versar sampled coal at 1/2-hour intervals for approximately 30 days.
- A Republic Steel preparation plant, where Versar sampled coal at one hour intervals for approximately 30 days.

The Republic plant processed coal from a single mine, and the R&F plant received coal from up to 40 strip pits and three different coal seams. In applying these results, one should be mindful of the physical conditions that the samples represent, and should not attempt to over-generalize these conclusions.

A preliminary analysis of the variability in coal data included a test for autocorrelation of the data which had given positive results in previously-analyzed coal data sets. For much of the data acquired in this study, strong autocorrelation was similarly indicated by this test. The 30-minute increment data from the R&F plant were more highly autocorrelated than composite data over longer time intervals. The data from the Republic plant exhibited weaker autocorrelation than the R&F data. However, the results from both plants confirm that serial correlation of coal data does in fact exist.

Two analytical techniques were utilized to quantify the correlated and random components of the variability in coal data: geostatistics and time-series analysis. Time-series models can be used in a predictive way to

generate data sets much longer than the empirical (measured) data set. The random component in the predictive model is obtained from a random number generator. Since this model is probabilistic, many different time series, equally likely, may be generated, all based upon the same mean, same variance, and same correlation structure. From a large number of time series based upon the model for the R&F-B/C coal data set, the average number of emission violations by a power plant burning this coal (either raw or cleaned) was determined.

For an emission limit 2.5 standard deviations greater than the mean, and for a 24-hour averaging time, 12 violations per year were predicted for raw coal and 49 for clean coal. These violation frequencies are very much greater than the frequency of 2 violations per year predicted from the (erroneous) assumption of serially-independent coal data. It should be emphasized that serially dependent and serially independent predictions are derived from the same mean and variance values for the coal.

Histograms were constructed for the raw and clean coals, based upon the measured R&F coal data and using the time-series predictive model. These histograms are useful in relating the number of expected violations per year for this coal, for any emission limitation. Also shown are the frequency curves based upon assumed data independence. The histograms based upon time series generation are broader, with higher tails, than the corresponding Gaussian curves, demonstrating that many more violations are expected with actual coal than under the misapplication of data independence.

Simultaneous sampling of both feed and product coals from each of two coal preparation plants, under carefully controlled conditions, has confirmed the results of prior studies: that both the mean total sulfur content and the mean emission parameter (lbs SO_2 per million Btu) are significantly reduced by the cleaning process:

		R&F Plant 30-Min Increments	Republic Plant 1-Hour Increments
Total Sulfur, Percent	Raw Coal	3.076	2.576
	Cleaned Coal	2.612	1.309
	Reduction	15.1%	49.2%
$\frac{\text{lbs SO}_2}{10^6 \text{ Btu}}$	Raw Coal	5.476	5.117
	Cleaned Coal	5.476	5.117
	Reduction	22.6%	63.4%

The extent of the reduction is quite different, however, for the two plants. A wide range of reductions among preparation plants is result consistent with prior findings.

Also confirming the results of prior studies, this investigation documented significant reductions, attributable to the coal preparation process, of the variability in total sulfur and in the emission parameter:

Measure	Parameter	R&F Plant (30-min Increments)			Republic Plant (1-hour Increments)		
		Raw Coal	Clean Coal	Percent Reduction	Raw Coal	Clean Coal	Percent Reduction
Variance	Total Sulfur, %	0.194	0.082	57.7	0.101	0.0072	92.9
	lb SO ₂ /10 ⁶ Btu	0.559	0.188	66.4	0.419	0.0172	95.9
Relative Standard Deviation	Total Sulfur, %	0.143	0.109	23.8	0.123	0.065	47.2
	lb SO ₂ /10 ⁶ Btu	0.137	0.102	25.5	0.126	0.070	44.4

Prior to analyzing the variability in coal data, the measurement uncertainty in the data was independently determined. This uncertainty, attributable to the process of sampling, compositing, sample preparation, and laboratory analysis, provides a quantitative limitation to subsequent explanations of coal variability. A comparison of analytical results, between physical composites and mathematical composites (covering the same time periods), provides a measure of the aggregate uncertainty from all of the aforementioned processes. In terms of the relative standard deviation (RSD) in percent total sulfur, these are:

	R&F Plant		Republic Plant	
Total Sulfur, %	Raw Coal	Clean Coal	Raw Coal	Clean Coal
Uncertainty	0.049	0.038	0.076	0.048
Total Variation	0.143	0.109	0.123	0.065

Also shown above are the RSDs for the total observed variations in total sulfur. All values for aggregate measurement uncertainty are significantly less than the total variations. Real variability in coal characteristics therefore was observed, over and above the measurement noise level.

The correlated and random components of variability in coal data were determined using two separate analytical techniques. The first is geostatistics, applied to the coal entering and leaving each preparation plant, since this temporal continuity of data corresponds to a spatial structural continuity of coal in the mine. Semivariograms were constructed, and values were derived for the random component of variance (the "nugget" value) and for the correlated component of variance (the difference between the total variance and the "nugget" variance). The second technique used for quantifying the correlated and random components

of variance is time-series analysis, in which a predictive model is constructed, based both upon earlier observations and upon a random component. Estimates for the random, or "white-noise," component of variance were made using time-series analysis.

The results of both analyses are summarized below:

Parameter	Data Set	Correlated Variance/Total Variance					
		Total Variance		Geostatistical Analysis		Time-Series Analysis	
		Raw	Clean	Raw	Clean	Raw	Clean
Percent	R&F-A	0.045	0.011	0.87	0.55	0.52	0.40
Total	R&F-B/C	0.196	0.079	0.44	0.54	0.27	0.40
Sulfur	Republic	0.101	0.007	0.24	0.29	0.10	0.16
	R&F-A	0.163	0.029	0.87	0.28	0.48	0.35
<u>Ibs SO₂</u>	R&F-B/C	0.643	0.195	0.38	0.49	0.11	0.34
<u>10⁶ Btu</u>	Republic	0.419	0.017	0.02	0.35	0.18	0.17

Although differences exist, the magnitudes and relative order among the data sets are the same for both types of analyses.

The time-series predictive model was also used to develop the effect of lot size upon variability. The data generated by the time series were mathematically composited into successively longer time intervals (corresponding to successively larger quantities of coal in each interval). The sample mean variance decreases with increasing lot size, but at a much smaller rate than would be expected from serially-independent data. This effect of lot size upon variability was confirmed by a preliminary analysis of the data, prior to the time-series analysis.

By mathematically compositing the coal characteristics data acquired at 30- or 60-minute increments into successively larger intervals of time, the variances and RSDs among intervals were determined for a succession of corresponding coal lot sizes. These RSDs, for percent total sulfur, for

heating values, for percent ash, and for emission parameter, were each normalized by dividing by the appropriate measurement uncertainty RSD. All values for normalized RSD-lot size data pairs, for all four coal characteristics, were observed to fall close to the same lines on a semilogarithmic plot. The least-squares lines of normalized RSD versus $\log_{10}$ (lot size, tons) for raw coals had steeper slopes than the lines for clean coals. The lines for raw coals from the two plants were approximately parallel, as were the lines for clean coals from the two plants.

SECTION 3.0

RECOMMENDATIONS

Serial dependence (also called autocorrelation) of coal characteristics must be incorporated into any analysis of the ability of either raw or cleaned coals to comply with SO₂ emission regulations. The misapplication of Gaussian statistics, which assumes serial independence of coal data, leads to a potential underestimation of the frequency of emission violations.

Time-series analysis, which combines serial dependence with a stochastic component to construct a predictive model for the variation of coal characteristics with time, provides an alternative to Gaussian statistics. The techniques and computer programs for applying time-series analysis are generally available for use.

Although the two diverse coals studied in detail both exhibited autocorrelation, the magnitude of the autocorrelation component of the total variance differed from one coal to another and from raw to cleaned coal. Therefore, each coal's ability to meet emission regulations must be determined separately.

Based on results from the two coal preparation plants intensively studied, one can expect the serial dependence of a coal to be adequately characterized by analysis of consecutive samples, each representing a 30- or 60-minute time increment, provided that the primary samples are each a full-stream cut obtained by an automatic sampler. Extension to 8 hours of the time interval between analyses does not appear acceptable, since the coal properties apparently have a shorter time lag of autocorrelation. Therefore, the conventional sample collection frequencies recommended by ASTM appear to be inadequate to characterize coal variability.

The duration of an intensive sampling and analysis study for a specific coal should be several days, sufficient to provide approximately 80 to 100 consecutive data points at a 30- or 60-minute frequency. The integrity of the consecutive data requirement is of utmost importance in characterizing autocorrelation, and requires that serial efforts be directed to avoiding data gaps. To verify the results and to evaluate longer term effects, the intensive study of several days should be repeated within a 30-day period. Although not used for the two preparation plants in this project, repeated intensive testing periods, each of several days, are recommended at regular intervals over a much longer time span (such as six months to a year) to characterize longer-term trends in coal characteristics.

In this study, approximately 1,000 samples of raw and cleaned coal were collected at regular and frequent intervals and under carefully controlled conditions. Much more data could be obtained from this large inventory of samples. Researchers concerned with other coal characteristics or constituents could gain valuable information from further analysis of these samples.

The results obtained from this study should be verified for other coals. In particular, coals from other regions and with higher and lower mean sulfur contents should be investigated. The additional studies should address coal feeds to power plants in order to characterize the time variation of coals responsible for boiler emissions. Those studies should include the effects upon variability of blending, stockpiling, and pulverizing at the power plants.

SECTION 4.0

EXPERIMENTAL APPROACH AND PROCEDURES

The experimental approach was designed to provide data to meet the objectives of the sulfur variability study described in Section 1. Raw and clean coal samples were collected simultaneously from coal preparation plants so that hour-to-hour and day-to-day changes in the coal characteristics could be monitored. These samples were collected and analyzed consistently during the study period using standard techniques so that the variance associated with sampling and analysis would not mask the coal characteristics. The data sets produced were of suitable size to allow application of Gaussian statistics, geostatistics, and time series analysis. This section describes the coal preparation plants that were sampled, the testing plans, and the analytical methods.

TEST SITES AND SAMPLING PROCEDURES

Rationale for Choice of Sites

The selection of preparation plants for sulfur variability testing was based upon the following criteria:

1. Automatic sampling equipment, conforming to ASTM specifications, on feed and product coals.
2. Plant layout that permits collection and handling of sample increments and sample lots.
3. A facility which could be tested for a 30-day period and still minimize the impact on normal preparation plant operations.

The task of finding candidate preparation plants began with the identification of facilities with operating sampling systems on the feed and product coal. Plants which had sampling systems on the feed coal generally

did not exercise the option to use them regularly, and therefore most of these systems were in a state of disrepair.

Because of these conditions, the following schedules and sites were selected:

- Samples for determination of sampling and analytical variance were obtained from Homer City Preparation Plant, Homer City, Pennsylvania.
- Variability Test 1 - R & F Coal Company Preparation Plant, Warnock, Ohio.
- Variability Test 2 - Republic Steel Corporation Kitt Mine No. 1 Preparation Plant, Philippi, West Virginia.

Experimental Determination of Sampling and Analysis Variance

Prior to any variability testing, the variance, V_{SA} , associated with sampling and analysis had to be determined. Obviously if the sampling and analysis variance were too large, variations in the coal characteristics might be lost as experimental noise. Therefore, the first task was to define V_{SA} .

Upper Freeport Seam raw coal was obtained from the Helen and Helvetia Mining Companies both located in Homer City, Pennsylvania. For each source, a 1200 lb. lot of coal was collected using a front-end loader. Each lot was stored, and shipped in four drums. This represented four identical samples, stored in separate containers for each source. Each sample was split and analyzed as indicated in Figure 4-1.

R & F Coal Company Preparation Plant

Coal Source and Type--

The first site selected for sulfur variability testing was the R & F Coal Company Preparation Plant located in Warnock, Ohio. The raw coal feed used at the R & F facility is a blend of numbers 8, 9, and 11 seam coals from company mines as well as coal purchased from contractors. U.S. Bureau of Mines proximate analysis data for coals in Belmont County, Ohio, are listed in Table 4-1.

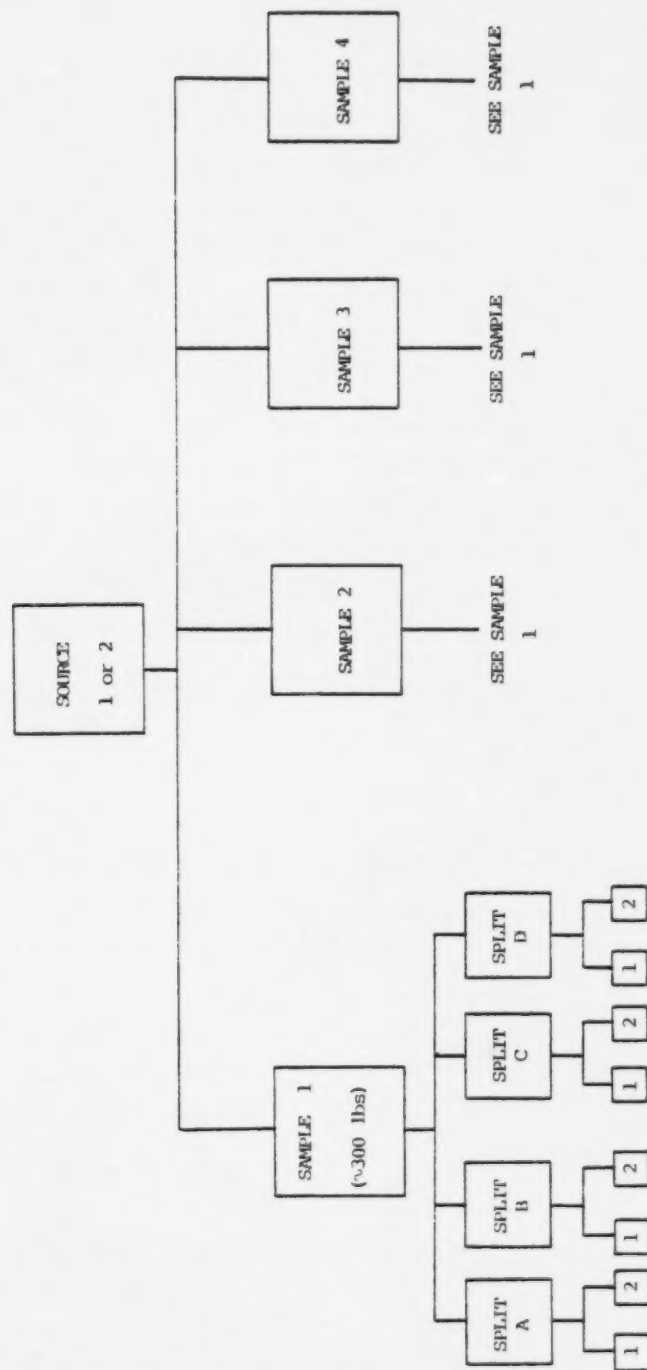


Figure 4-1. Experimental calibration sample division scheme.

TABLE 4-1. USBM COAL PROXIMATE ANALYSIS (BELMONT COUNTY, OHIO)*

NO. 8 SEAM

Reserve Base - Deep 2431.25 x 10⁶ Tons; Strip 209.57 x 10⁶ Tons

Proximate Analysis:

<u>Raw</u>	<u>High</u>	<u>Low</u>	<u>Mean</u>
Moisture (%)	12.9	1.4	3.6
Vol. Matter (%)	44.6	36.6	40.4
Fixed Carbon (%)	52.8	42.1	48.9
Ash (%)	20.9	6.2	10.5
Sulfur (%)	6.2	2.0	3.9
Heating Value, Btu/lb	13,870	11,410	13,140

NO. 8-A SEAM

Proximate Analysis:

Moisture (%)	6.7	3.5	4.7
Vol. Matter (%)	39.3	37.3	38.6
Fixed Carbon (%)	50.2	47.3	48.1
Ash (%)	14.0	11.4	13.2
Sulfur (%)	5.3	1.9	3.8
Heating Value, Btu/lb	13,000	12,510	12,590

*U.S. Coal Mine Production by Seam - 1980, Keystone Coal Industry Manual

(Continued)

TABLE 4-1. USBM COAL PROXIMATE ANALYSIS (BELMONT COUNTY, OHIO)*

(CONTINUED)

NO. 9 SEAM

Reserve Base - Deep 1081.96 x 10⁶ Tons; Strip 81.9 x 10⁶ Tons

Proximate Analysis:

<u>Raw</u>	<u>High</u>	<u>Low</u>	<u>Mean</u>
Moisture (%)	5.3	1.8	4.0
Vol. Matter (%)	41.6	37.3	39.4
Fixed Carbon (%)	50.2	44.8	47.7
Ash (%)	15.3	11.1	12.7
Sulfur (%)	4.4	1.8	3.1
Heating Value, Btu/lb	13,060	12,280	12,710

NO. 11 SEAM

Reserve Base - Deep 337.86 x 10⁶ Tons

NO USBM ANALYSIS AVAILABLE

*U.S. Coal Mine Production by Seam - 1980, Keystone Coal Industry Manual

Plant Description--

The R & F Coal Company Preparation Plant is a level 4 beneficiation process using a Roberts and Schaefer design. This type of process consists of:

- Crushing the raw coal to a 4 inch topsize.
- By-passing the minus 3/4 inch material by wet screening.
- Cleaning the 4 x 3/4 inch material in twin dense medium vessels.
- Cleaning the 3/4 inch x 28 mesh material with dense medium cyclones.
- Cleaning the 28 mesh x 0 material with classifying and hydrocyclones.

Raw coal is trucked and loaded into hoppers which feed the rotary breaker. The crushed feed is deposited onto one of two 12,000 ton or one 25,000 ton storage pile depending upon the coal seam. Feeders located under each pile supply the desired seam of raw coal or a blend to the cleaning plant.

The processed coal leaves the cleaning plant via conveyors to a series of four 5,000-ton storage silos. Through a rigorous quality control program, consisting of the proximate analysis of clean coal samples collected every 30 minutes, the average sulfur concentration and heat content value in each 5,000 ton silo is calculated. Clean coal is blended from each silo so that the average sulfur concentration and emission rate ($\text{lbs. SO}_2/10^6 \text{ Btu}$) meet contract specifications. The coal is shipped via rail and truck approximately 20 miles to an Ohio River loading terminal where the material is sold and transported in 5 barge lots. The barges transport the coal to Alabama where it is primarily used in utility boilers.

Nominal Plant Data--

The R & F Preparation Plant operates on a 24-hour per day, 5 day production week or until a weekly quota of 50,000 tons of clean coal has been produced. During the period the preparation plant was sampled, April 22, 1980 through June 6, 1980, 438,448 tons of feed coal came into

the plant and 338,589 tons of clean coal were produced. These production figures indicate a 48,370 ton weekly average at a yield of 77%.

Sampling Equipment--

The feed and product conveyors were both equipped with automatic sampling systems. The configuration of the systems is similar to the design depicted in Figure 4-2. The raw coal primary sampler takes periodic cuts of the 4-inch x 0 feed material, reduces it to 28 mesh x 0 in a hammermill crusher, and splits it again through the secondary sampler. The sample collection vessel was left in place for 8 production hours to collect the composites; the vessel was removed every 30 minutes during the intensive study. The clean coal sampling system is similar to the feed system except the clean coal being sampled has a topsize of 2 inch x 0. Both primary samplers were programmed to take cross-sectional cuts every six to seven minutes.

Sample Collection Frequency--

The sampling scheme used at R & F Coal Company was designed to provide as much information on the characteristics of varying lot sizes as possible. Samples were collected at 30-minute increments during two intensive efforts for 22 and 40 hours, respectively. Concurrently, 8-hour composites were collected during the entire study period. Table 4-2 details these sampling activities. These sampling frequencies and time composites represent clean coal lot sizes based upon an average 660 tons/hour production rate. Therefore, a 30-minute increment sample represents a 330 ton lot, an 8-hour composite represents 5,280 tons of clean coal, and a weekly composite is equivalent to a 48,000 ton lot size.

Republic Steel Corporation Kitt Mine No. 1 Preparation Plant

Coal Source and Type--

The Republic Steel Corporation coal preparation plant in Philippi, West Virginia, is located in Barbour County at the mouth of the Kitt No. 1 Mine. The deep-mined feed coal is from the Lower Kittanning Seam which is a utility and coke-blend coal, the lowest of the three Kittanning Coals. The Lower Kittanning Seam covers an area of about 2,640 square miles in

COAL PREPARATION

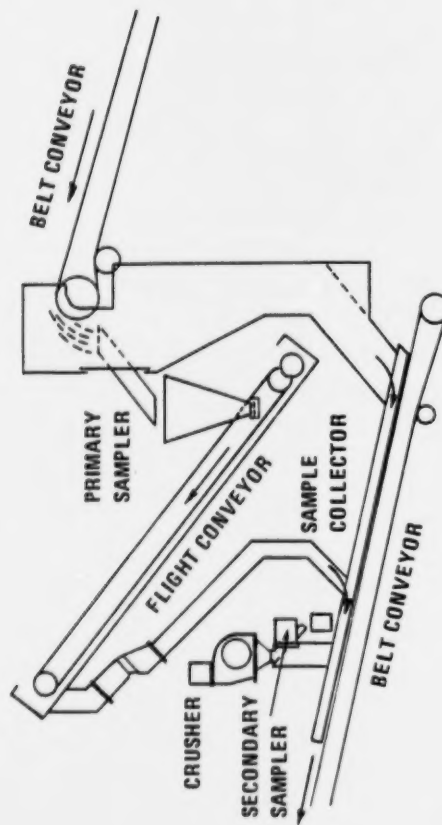


Figure 4-2. Automatic sampling system at R&F Plant.

TABLE 4-2. SAMPLING ACTIVITIES AT R&F COAL COMPANY

<u>WEEK</u>	<u>Number of 8-Hour Intervals Collected</u>	<u>Comments</u>
4/22-4/25	11	
4/28-5/1	5	Samples collected at 30-minute increments for 22 Hours. (Net 44)
5/5-5/6	3	
5/12-5/16	No Samples	Plant not operating.
5/19-5/23	7	Samples collected at 30-minute increments for 40 Hours. (Net 80)
5/23-5/30	No Samples	Feed coal automatic sampler inoperative.
6/2-6/6	8	
TOTAL	34	124

West Virginia, and the original minable tonnage is estimated to have been over a billion tons. The coal is in multiple beds two to twelve feet thick, with beds averaging about five feet. Proximate analysis from two data bases is available and is listed in Table 4-3.

TABLE 4-3. LOWER KITTANNING COAL PROXIMATE ANALYSIS*

<u>RAW</u>	<u>HIGH</u>	<u>LOW</u>	<u>MEAN</u>
Moisture (%)	4.3	2.2	3.1
Vol. Matter (%)	29.6	28.4	29.2
Fixed Carbon (%)	58.6	56.1	57.5
Ash (%)	14.4	11.9	13.1
Sulfur (%)	1.2	0.8	0.9
Heating Value, Btu/lb	13,580	13,170	13,350

<u>RAW</u>	<u>HIGH</u>	<u>LOW</u>	<u>MEDIAN</u>	<u>90% LIMITS</u>
Vol. Matter (%)	48	16	34	25-41
Fixed Carbon (%)	72	41	55	50-64
Ash (%)	26	2	9	2-13
Sulfur (%)	9.0	0.4	1.0	0.4-2.5
Heating Value, Btu/lb	15,600	11,600	13,500	12,700-14,400

* U.S. Coal Mine Production by Seam - 1980, Keystone Coal Industry Manual.

Plant Description--

The Kitt Mine Preparation Plant features heavy medium vessels, deister tables, and flotation cells in this Roberts and Schaefer design. This beneficiation process consists of:

- Crushing the raw coal to a topsize of 1 1/2 inches.
- Separating the coal into two size fractions: 1 1/2 x 5/16 inches and 5/16 inches x 0.
- Wet beneficiation of the 1 1/2 x 5/16-inch material in dense medium vessels.
- Dewatering and separating the 5/16-inch x 0 fraction into two size fractions: 5/16-inch x 28 mesh and 28 mesh x 0.
- Cleaning the 5/16-inch x 28 mesh material with twenty double deck deister tables.

- Cleaning the 28 mesh x 0 material in two banks of four flotation cells.
- Dewatering of coarse and middlings by centrifugation, and vacuum filtering of the fines following flotation.

Raw coal exits the Kitt No. 1 Mine near the preparation plant, is crushed to 1 1/2 inch x 0, and is transferred to a storage pile. Feeders under the raw coal storage pile supply coal to twin plant feed belts at a designed rate of 1,000 tons per hour.

The processed coal leaves the plant via a series of conveyors to a clean coal storage pile. Clean coal is transported by conveyor to a loadout bin which in turn fills railroad cars. The product coal is primarily used for metallurgical applications.

Nominal Plant Data--

The Kitt Mine No. 1 Preparation Plant operates on a six to eight hour per day, five-day production week schedule. During the period, the preparation plant was sampled, July 21, 1980 through August 15, 1980, 102,130 tons of feed coal came into the plant and 58,652 tons of clean coal were produced. These production figures indicate a 458-ton hourly average of clean coal at a yield of 57%.

Based upon the screen analysis of the feed coal for plant design, approximately 55% of the feed is 5/16-inch x 0 size material. The designed material balance of the facility is shown in Table 4-4.

TABLE 4-4

KITT MINE NO. 1 PREPARATION PLANT MATERIAL BALANCE

<u>Product</u>	<u>Size Fraction</u>	<u>Dry Weight (Tons/Hour)</u>	<u>Associated Moisture (Gallons/Minute)</u>
Clean Coal	1 1/2" x 5/16"	276	30
	5/16" x 28 mesh	367	110
	28 mesh x 0	97	115
(Total)	1 1/2" x 0	740	255
Refuse	1 1/2" x 5/16"	171	65
	5/16" x 28 mesh	65	65
	28 mesh x 0	24	40
(Total)	1 1/2" x 0	260	170

Sampling Equipment--

The feed and product conveyors were both equipped with primary sampling devices only. Unlike the system depicted in Figure 4-2, the samplers at Republic Steel primarily consisted of a cutter which emptied the material into a hopper for acquisition. The sampler was activated manually through a relay control mechanism. The cutter blade was allowed to traverse the coal stream and return, emptying both sample cuts into a storage hopper. The size of the sample was proportional to the amount of coal on the belt. Normally, this back and forth series of cross-stream cuts produced 200 lbs. of sample material. No crushing took place during this operation; therefore the topsize of both the feed and product coals was 1 1/2-inch x 0.

Sample Collection Frequency--

The sample scheme used at Kitt Mine No. 1 Preparation Plant was designed to provide as many samples or data points as possible during a production day. This is particularly important because grab samples were being collected every half-hour or hour. The factor that determined the sampling frequency was a physical constraint, the time required to empty the sample hopper. Twenty minutes were required to transfer the sample to a riffle splitter and reduce the entire 200 lb. sample to a five to seven lb. working sample. The time required to activate the sampler plus the time required for processing precluded collecting samples more frequently than every 30 minutes.

Table 4-5 illustrates the sampling activities at Kitt Mine No. 1. Samples were collected hourly during weeks one and four and on the half-hour during weeks two and three. The data can therefore be compiled to represent hourly samples for the continuous four week period and half-hour samples for a continuous two week span.

Based upon an average clean coal production rate, hourly samples represent 458 tons of coal; a daily composite (6.4 hrs.) represents 2,932 tons; and a weekly composite is equivalent to 14,663 tons of clean coal.

TABLE 4-5. SAMPLING ACTIVITIES AT KITT MINE NO. 1

Date	Sample Code Series	No. of Samples				Composites		
		Raw Coal		Clean Coal		Raw Coal	Clean Coal	
		Hourly	1/2 Hour	Hourly	1/2 Hour			
7/21	21	5		2		D	D	
7/22	22	6		6		D	D	
7/23	23	7		7		D	D	
7/24	24	5		7		D	D	
7/25	25	7		7		D/W	D/W	
End of Week 1		30		29		Weekly Subtotal		
7/28	26		11		10	D	D	
7/29	27		14		15	D	D	
7/30	28		14		15	D	D	
7/31	29		15		15	D	D	
8/1	30		8		13	D/W	D/W	
End of Week 2			62		68	Weekly Subtotal		
8/5	31		11		11	D	D	
8/6	32		14		14	D	D	
8/7	33		14		14	D	D	
8/8	34		13		13	D/W	D/W	
End of Week 3			52		52	Weekly Subtotal		
8/11	35	4		5		D	D	
8/12	36	7		7		D	D	
8/13	37	7		8		D	D	
8/14	38	8		8		D	D	
8/15	39	8		8		D/W/M	D/W/M	
End of Week 4		34		36				
TOTALS		178 raw coal		185 clean coal				

Legend = D = Daily composite
W = Weekly composite
M = Monthly composite

SAMPLE PREPARATION AND ANALYSIS PROCEDURES

Subsampling Procedure and Composite Preparation

Each coal sample collected from the sampling system was riffled, crushed, riffled again, air-dried, pulverized, and riffled a final time to produce a representative analytical sample. ASTM procedure D2013, "Preparing Coal Samples for Analysis," was the reference used in deriving the sample division as illustrated in Figure 4-3. Concurrent with the sample preparation procedure, reject portions of selected split samples were retained for daily, weekly, and monthly composites. The individual aliquots used to make up the various composites were proportioned to the coal feed rate or production rate rather than using a constant weight for each aliquot.

The analytical samples, once air-dried, were reduced to minus 60 mesh using a Holmes Model 500 pulverizer. This material was split into two fractions and sealed in separate containers. One bottle was used for immediate coal analysis and the other was kept as a library sample for future use.

Laboratory Analysis Procedures--

All raw and clean coal samples were analyzed for total sulfur, pyritic sulfur, heat content, ash and moisture using the following ASTM standard procedures:

<u>Test</u>	<u>Reference</u>	<u>Comment</u>
Total Sulfur	- Leco, High Frequency Combustion Titration - ASTM, D3177-75	
Pyritic Sulfur	- ASTM, D2492-79	Atomic absorption method for iron determination
Heat Content	- ASTM, 2015-77	
Ash	- ASTM, 3174-73	
Moisture	- ASTM, 3302-74 - ASTM, 2961-79	Air-dry loss and residual moisture; total moisture by calculation Total moisture by direct determination

The specific analytical procedures are detailed in Appendix B.

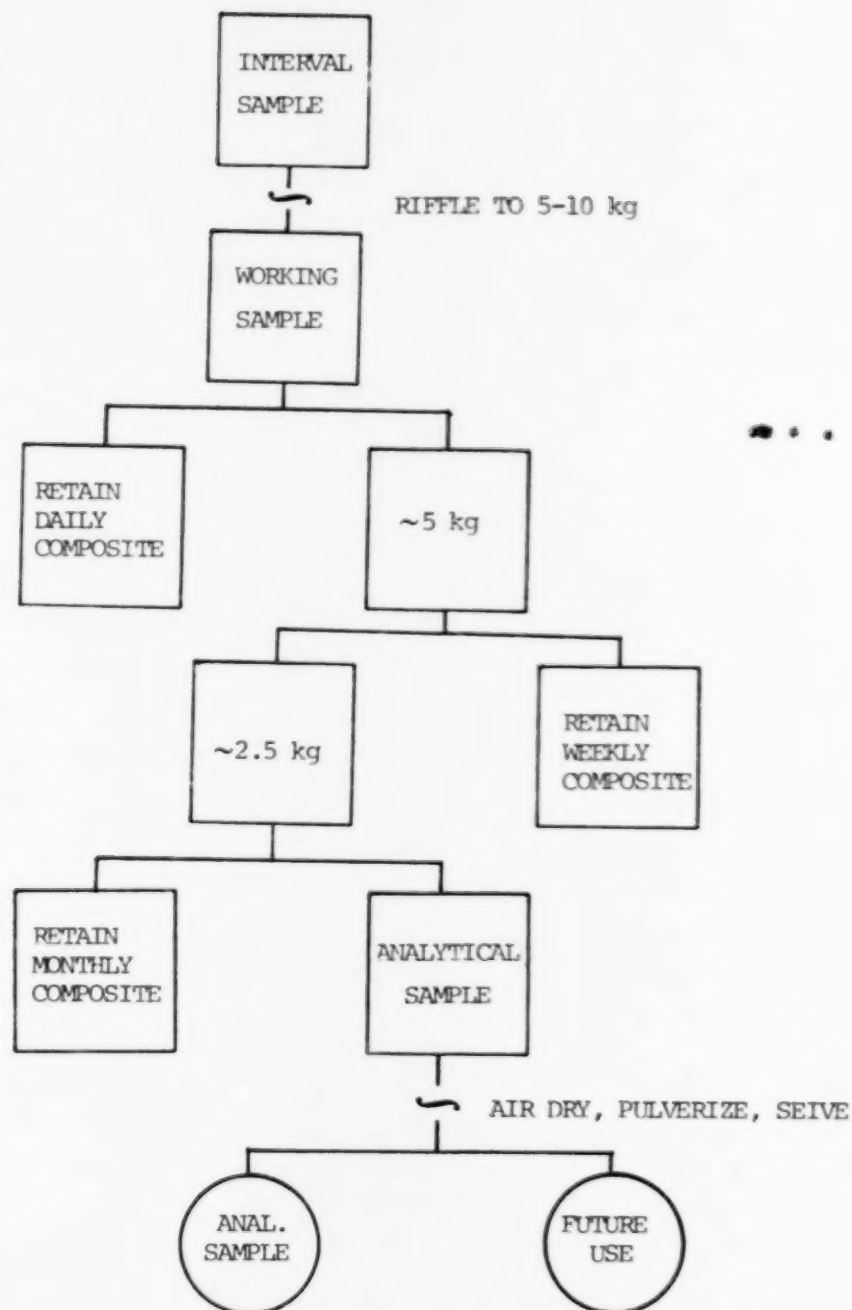


Figure 4-3. Daily sample division.

Quality Control Program--

The quality control (QC) program was designed to ensure that coal analysis data are precise and accurate. To meet this objective, the QC program is divided into two areas: laboratory QC and data QC.

During the experimental calibration of this program and prior to any field testing, each analytical method was evaluated. Based upon the replicate analysis of samples with varying concentrations, quality control charts for each parameter were constructed using procedures outlined in an EPA quality control manual (EPA 600/4-79-016). These range control limits, R_C , appear at the end of each analytical procedure. Every sample was analyzed in duplicate, and the difference between these duplicates could not exceed the R_C value for that particular test. Major outliers were identified and re-analyzed. Differences between duplicates which were within $\pm 20\%$ of R_C value were also evaluated by comparison of samples collected at nearly the same time period. Again, in cases of major discrepancies, samples were re-analyzed.

The data quality control procedure is based upon the use of one form to record the analytical data for each parameter without the use of any intermediate calculations. For example, the analyst's records of all of the weights, instrument readings, etc., were placed on a form similar to Table 4-6. When all of the tests had been completed, the data were entered into a programmable calculator; an example of the results is shown in Figure 4-4. The analytical results are expressed in several terms: as-determined basis, as-received basis (AR), dry weight basis, and dry ash-free basis (DAF). Comparisons of duplicates were made at this point, and samples were re-analyzed as necessary.

Sampling Schedules

The sampling test plans which were developed for the R & F and Republic Steel preparation plants were designed to measure the variability among different lot sizes or increments of coal. The limiting factor in determining the smallest lot size which could be sampled generally was the amount of time required to activate the sampler, empty the collection

TABLE 4-6. EXAMPLE OF ANALYSIS DATA SHEET

SITE	KITT MINE NO. 1		DATE	9/17/80	
TYPE OF SAMPLE	ROM COAL				
	1	SAMPLE NO.	37301.1		
TOTAL MOISTURE (TM)	{	2	PAN (NO. 11)	9.6350	g
		3	PAN + SAMPLE	109.3874	g
		4	PAN + DRIED SAMPLE	99.3470	g
RESIDUAL MOISTURE (RM)	{	5	CRUCIBLE (NO.)	11.0879	g
		6	CRUCIBLE + SAMPLE	12.0883	g
		7	CRUCIBLE + DRIED SAMPLE	12.0823	g
ASH	8	CRUCIBLE + ASHED SAMPLE	11.3484	g	
TOTAL SULFUR	{	9	CRUCIBLE + V ₂ O ₅ (NO.)	19.6248	g
		10	CRUCIBLE + V ₂ O ₅ + SAMPLE	19.7251	g
		11	BURET READING	0.127	
BTU	{	12	CRUCIBLE	11.8834	g
		13	CRUCIBLE + SAMPLE PELLET	12.8855	g
		14	INITIAL TEMPERATURE	23.733	°C
		15	FINAL TEMPERATURE	26.323	°C
		16	FUSE BURNT	16	cal.
		17	Na ₂ CO ₃ TITRANT	8.0	ml
PYRITIC SULFUR	{	18	FLASK (NO. 16)	0	g
		19	FLASK + SAMPLE	5.046	g
		20	IRON CONCENTRATION	255	mg/l
ADDITIONAL INFORMATION:					
	1	A', IODATE FACTOR k (k x .444 g/l)	2		
	2	B', f FACTOR (COMPARISON TO STD.)	1.11		
	3	C', WATER EQUIVALENT (W)	2407	cal/°C	

37301.1		Sample Identification Code
9.635	}	Input Data for Total Moisture or Air-Dry Loss
109.3874		
99.347		
10.07		% TM
11.0879	}	Input Data for Residual Moisture
12.0883		
12.0823		
0.60		% RM
11.3484	}	Input Data for Ash
26.04		Ash
24.99		% AR
26.20		Dry
19.6248	}	Input Data for Total Sulfur
19.7251		
0.127		
2.81		% TS
2.70		% AR
2.83		Dry
3.83		Daf
11.8834	}	Input Data for Heat Content
12.8855		
23.733		
26.323		
16.		
8.		
11083.97		Btu
10635.68		% AR
11150.85		Dry
15108.88		Daf
LBS SO ₂ /MM		Btu - Pounds SO ₂ per million Btu
5.07		
0.	}	Input Data for Pyritic Sulfur
5.046		
255.		
1.45		% PS
1.39		% AR
1.46		Dry
1.98		Daf
1.38		% OS - percent organic sulfur
0.49		O/T - organic to total sulfur ratio
9.26		A/T - ash to total sulfur ratio

Figure 4-4. Example of analysis data report sample identification code.

hopper, and riffle the material. Variance between larger lot sizes can easily be derived by physically compositing individual increments or mathematically combining smaller lot size increments. Physical composites were prepared representing 8 hour lots, entire production days, production weeks, and a 20-day production period. Because of the large number of samples to be collected, a unique sample coding system was established. Appendix C, Section C.1 describes the sample codes for the 8-hour composites of raw and clean coal collected at R & F Coal Company. Sections C.2 and C.3 represent the codes for raw and clean coal collected at 30-minute increments during the intensive studies. The sample codes for the weekly and monthly composites are illustrated on Section C.4.

The Republic Steel Corp. samples use a similiar type of coding system except in this system, the first day is indicated by 21. Appendix C, Sections C.5 and C.6 detail the codes for the raw and clean coal samples, and Section C.7 gives the codes for physical composite samples. Samples were collected at 30-minute increments during days six through fourteen and are indicated by consecutive sample code numbers.

SECTION 5.0

DATA BASE

This section presents characteristic coal data which were produced by the analysis of raw and clean coal samples from two commercial coal cleaning plants. Close attention has been paid to the testing and quality control programs to ensure that data will meet the objectives of the study.

The raw and clean coal samples which were collected at the R & F Coal Company and Republic Steel Corporation plants were analyzed for total sulfur, pyritic sulfur, heating value, ash content, and moisture. Moisture analysis of R & F Coal samples consisted of air dry weight loss determination followed by residual moisture analysis and calculation of total moisture. Because of equipment considerations, the Republic Steel samples were analyzed for total moisture directly, and a separate portion of the sample was air dried and used for a residual moisture determination. The end result provided the same information, but in one case it was a calculation, in the other it was a direct measurement.

All analytical tests were performed on air-dried material which had been pulverized to minus 60 mesh. The concentration of each constituent was reported on an as-determined basis (AD) and reflects the amount of moisture remaining in a sample after it has come to equilibrium in an open container at room temperature. These concentrations have been corrected for the amount of residual moisture left in the sample and therefore are expressed on a dry basis. Conversions, using total and residual moisture, have been applied to the as-determined data to express the concentration in terms of (1) the moisture present at the time the sample was collected or (2) the as-received basis. Finally, using total moisture and ash content, the data have been converted to a dry ash-free basis (DAF).

The reported values for sulfur dioxide emission rate are calculated based upon the total sulfur concentration and heating value (Btu/lb). Assuming the complete stoichiometric conversion of sulfur in coal to sulfur dioxide (i.e., no sulfur retention in the ash), the emission rate is equal to:

$$\text{Emission Rate (lbs SO}_2\text{/Btu} \times 10^6) = \frac{1.998 \times \text{TS}}{\text{HV}} \times 10^4$$

TS = Total Sulfur, % (dry)
HV = Heating Value, Btu/lb (dry)

The statistical summaries presented in this section are based upon the Gaussian approach where:

N = number of observations of x

$$\bar{x} = \text{mean} = \frac{\sum_{i=1}^N x_i}{N}$$

$$S^2 = \text{total variance} = \frac{\sum_{i=1}^N (x_i - \bar{x})^2}{N-1} = \frac{\sum_{i=1}^N x_i^2 - \left(\sum_{i=1}^N x_i \right)^2}{N-1}$$

S = standard deviation of $\bar{x}$

RSD = relative standard deviation = $S/\bar{x}$

The analytical results of each pair of duplicate analyses were averaged to obtain a single data point:

$$x_1 = \frac{x_{1.1} + x_{1.2}}{2}$$

Analytical variance, S_a^2 , was calculated as follows:

$$S_a^2 = \frac{\sum_{i=1}^N \left(x_{i.1} - x_{i.2} \right)^2}{2N}$$

Duplicate composite samples were treated in the same manner.

In this section, the data from R & F Coal Company and Republic Steel Corporation are presented in a graphical format. The data are also listed in a tabular form in Appendix A and are specifically referenced in the descriptions for each data set.

ANALYSIS OF SAMPLES COLLECTED AT R & F COAL COMPANY

As described in Section 4, from April 22 through June 6, 1980, raw and clean coal samples were collected at the R & F Coal Company preparation plant. During this period, 34 eight-hour composites of both raw and clean coal were collected, and two separate intensive studies were performed during which samples were collected at 30-minute intervals for 22 and 40 hours, respectively. Each 8-hour or 30-minute interval sample was blended to produce daily, weekly, and monthly composites. These data sets will be presented individually.

30-Minute Incremental Data for 22-Hours (Study A)

Figures 5-1 through 5-4 are plots of the raw and clean coal data for the 22-hour intensive study. Figure 5-5 illustrates the calculated sulfur dioxide emission rates. A statistical summary of the raw and clean coal data is presented in Table 5-1. All results expressed in this section are on a dry weight basis. The results of each duplicate analysis can be found in Appendix A, Section A.1.

From the statistical summary and the individual data plots, it is seen that the quality of the processed coal has been enhanced. The percent reduction (or enhancement) between the raw and clean coals for each parameter is given below. Negative values indicate reduction in percent from raw to clean coal and plus values indicate enhancement.

<u>Parameter</u>	<u>Percent Change in $\bar{x}$</u>
Total Sulfur	- 15
Pyritic Sulfur	- 21
Organic Sulfur	- 7
Heating Value	+ 9
Ash Content	- 32
Emission Rate	- 23

The reduction in variance for total sulfur, pyritic sulfur, ash and emission rate seen in Table 5-1 clearly implies that coal cleaning attenuates the variability of the measured constituents in the coal.

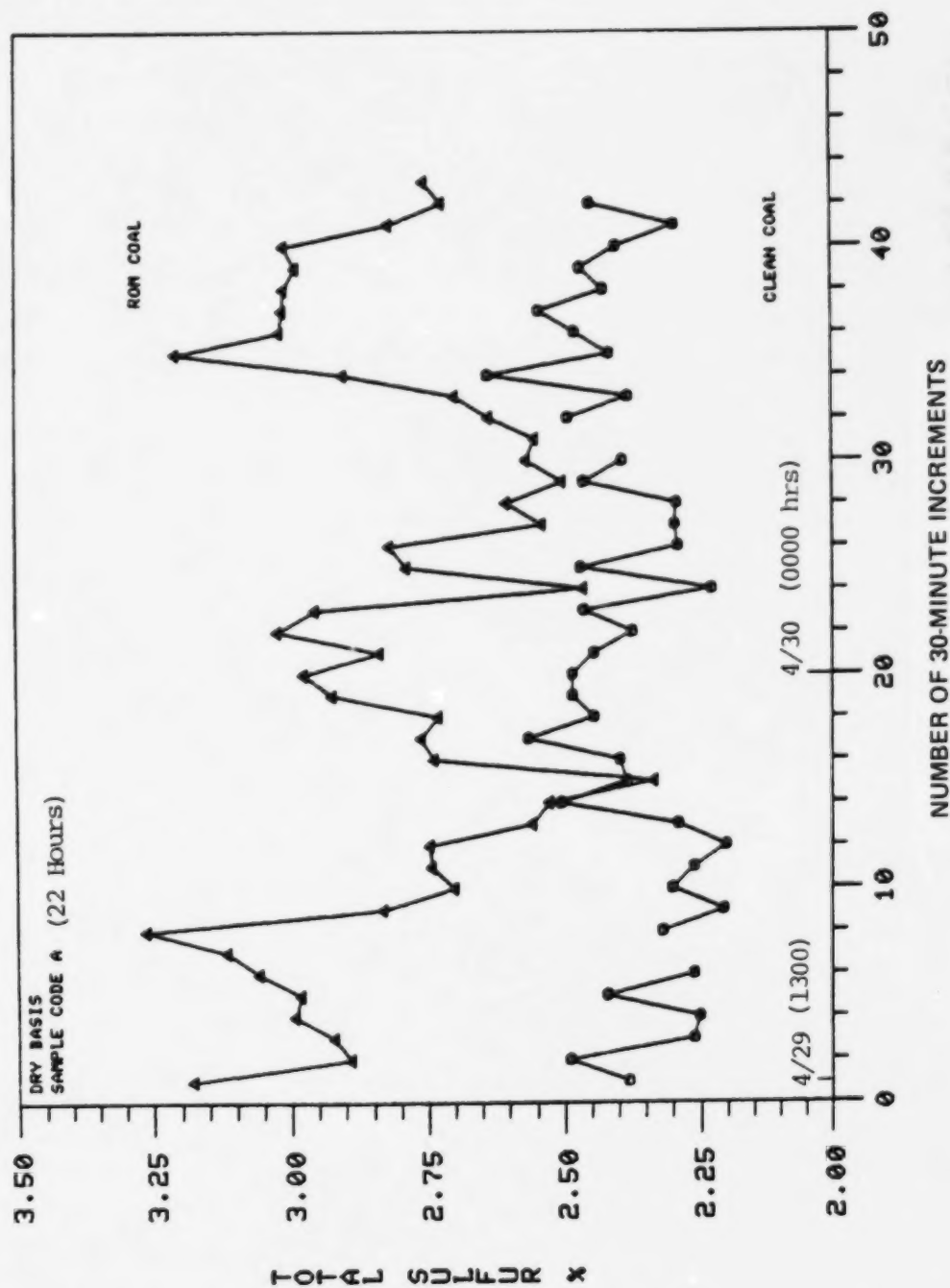


Figure 5-1. R&F Coal Company - 30-minute increment data for total sulfur.

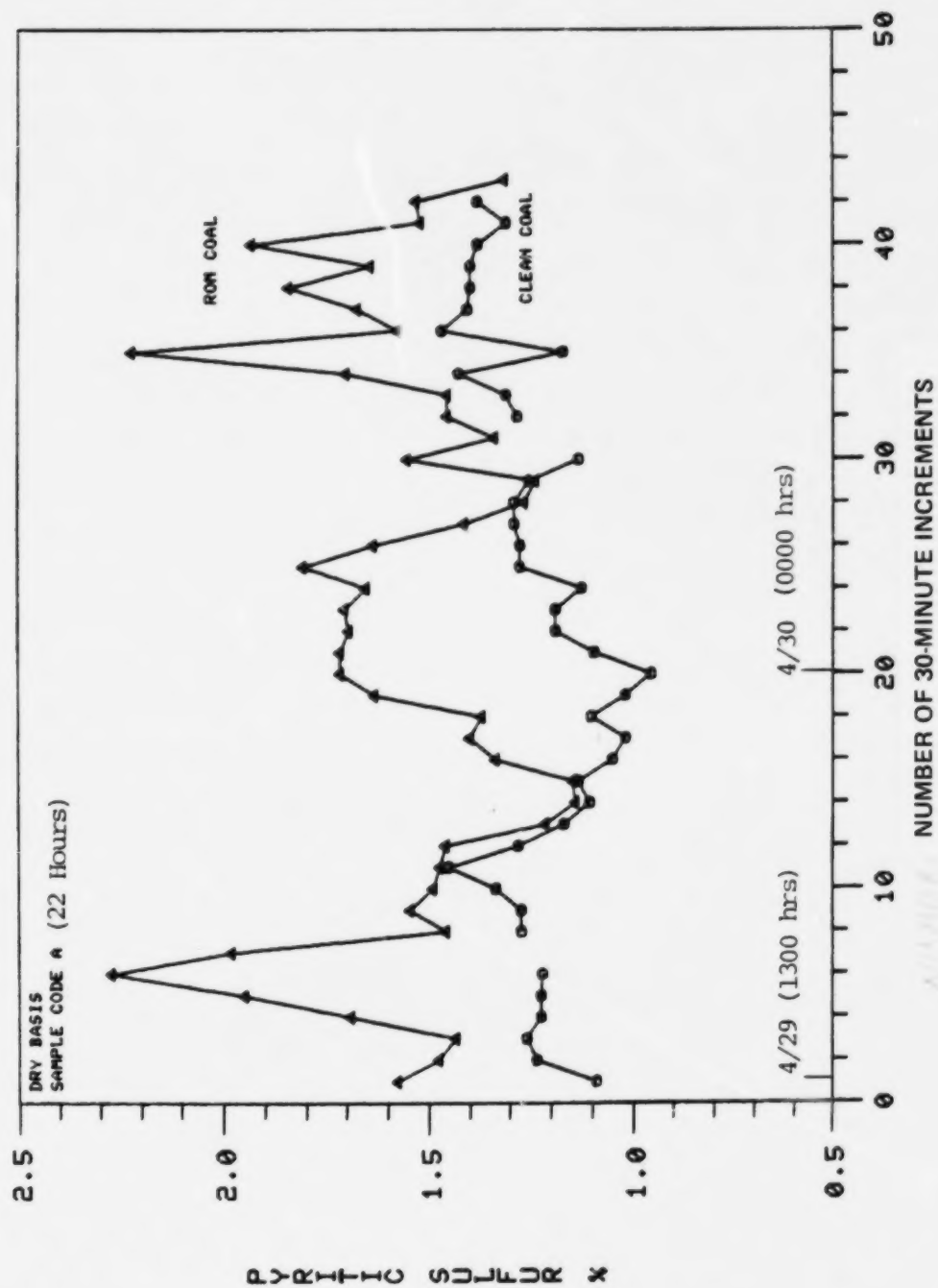


Figure 5-2. R&F Coal Company - 30-minute increment data for pyritic sulfur.

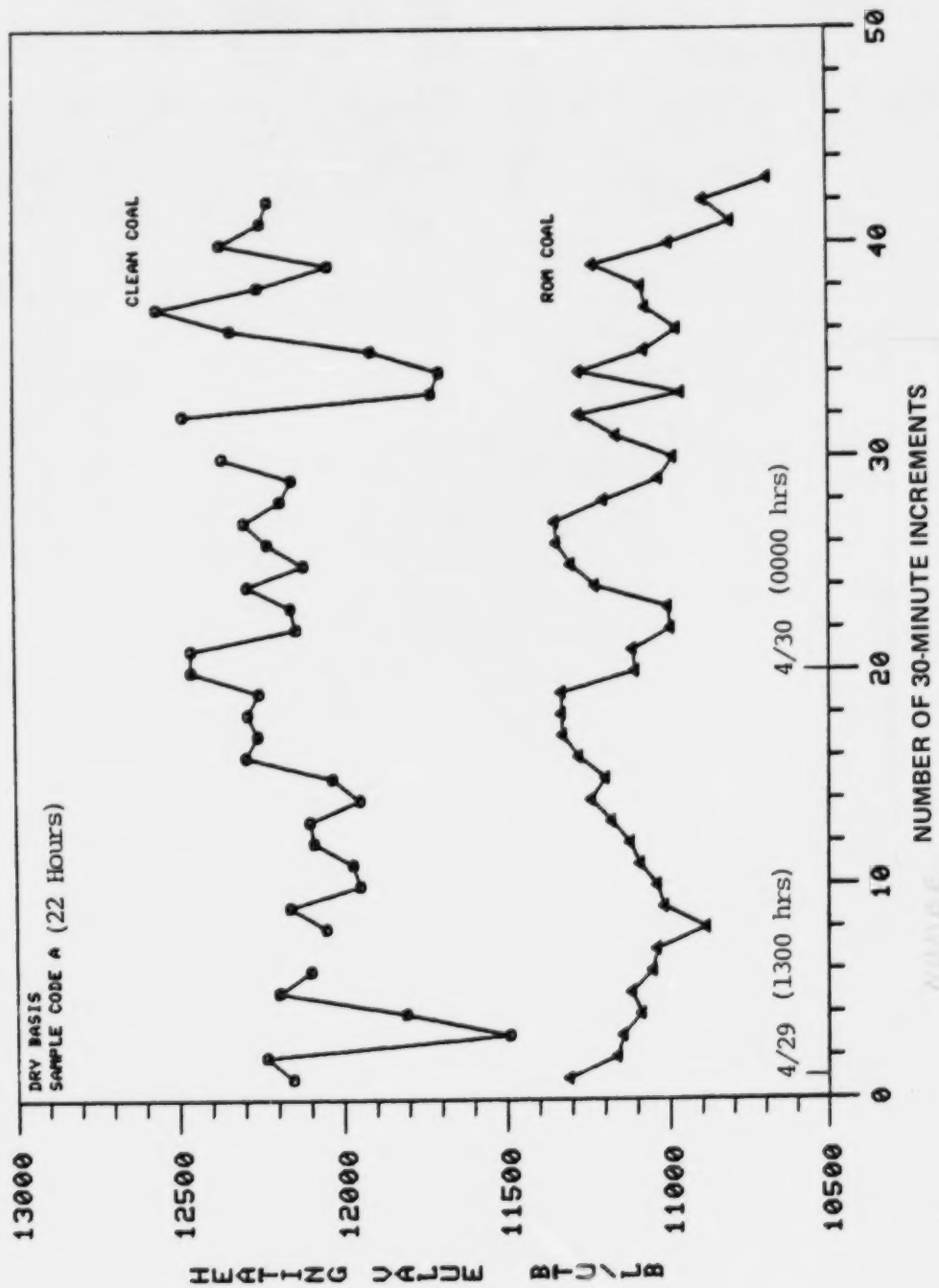


Figure 5-3. R&F Coal Company - 30-minute increment data for heating value.

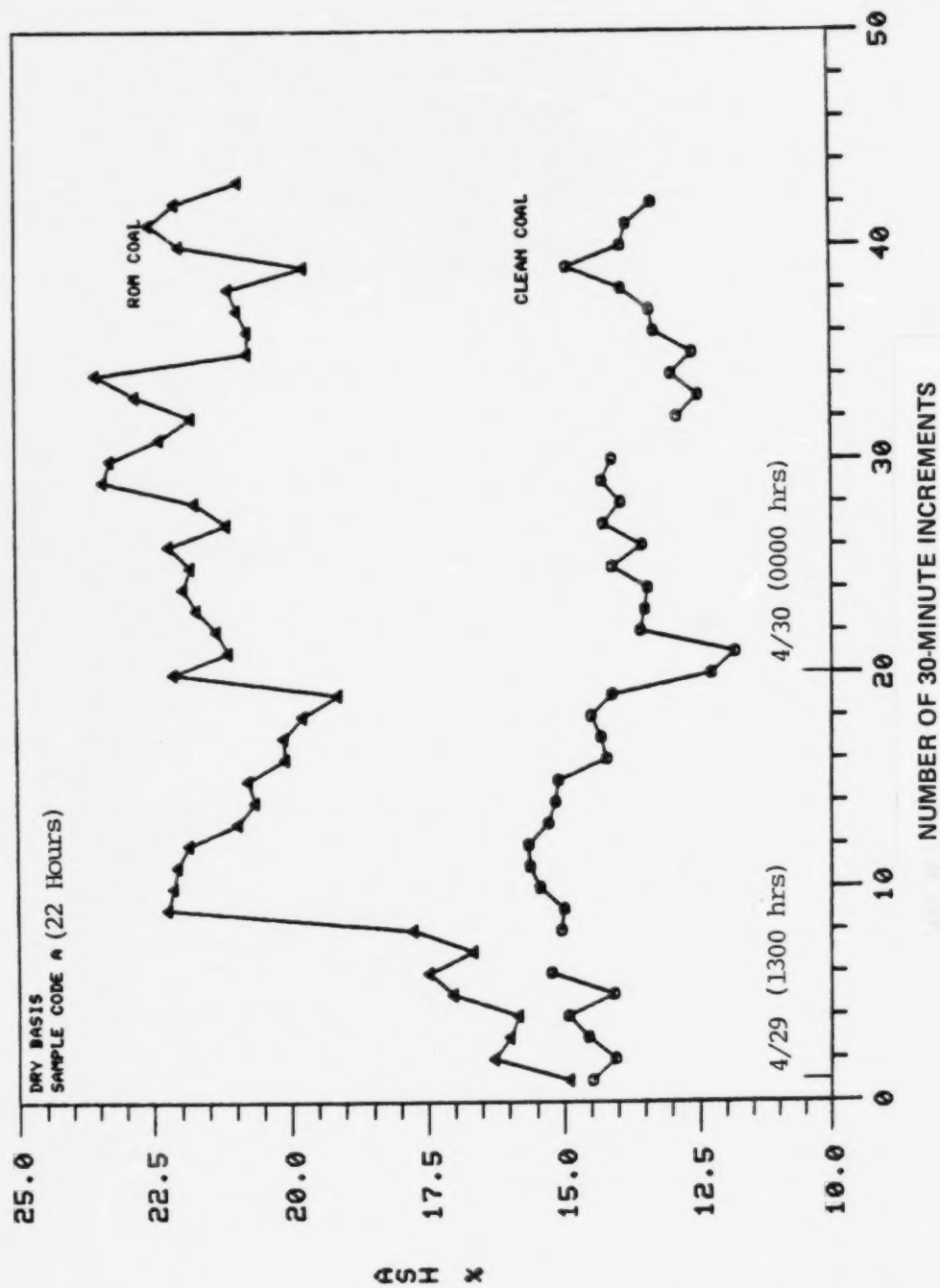


Figure 5-4. R&F Coal Company - 30-minute increment data for ash content.

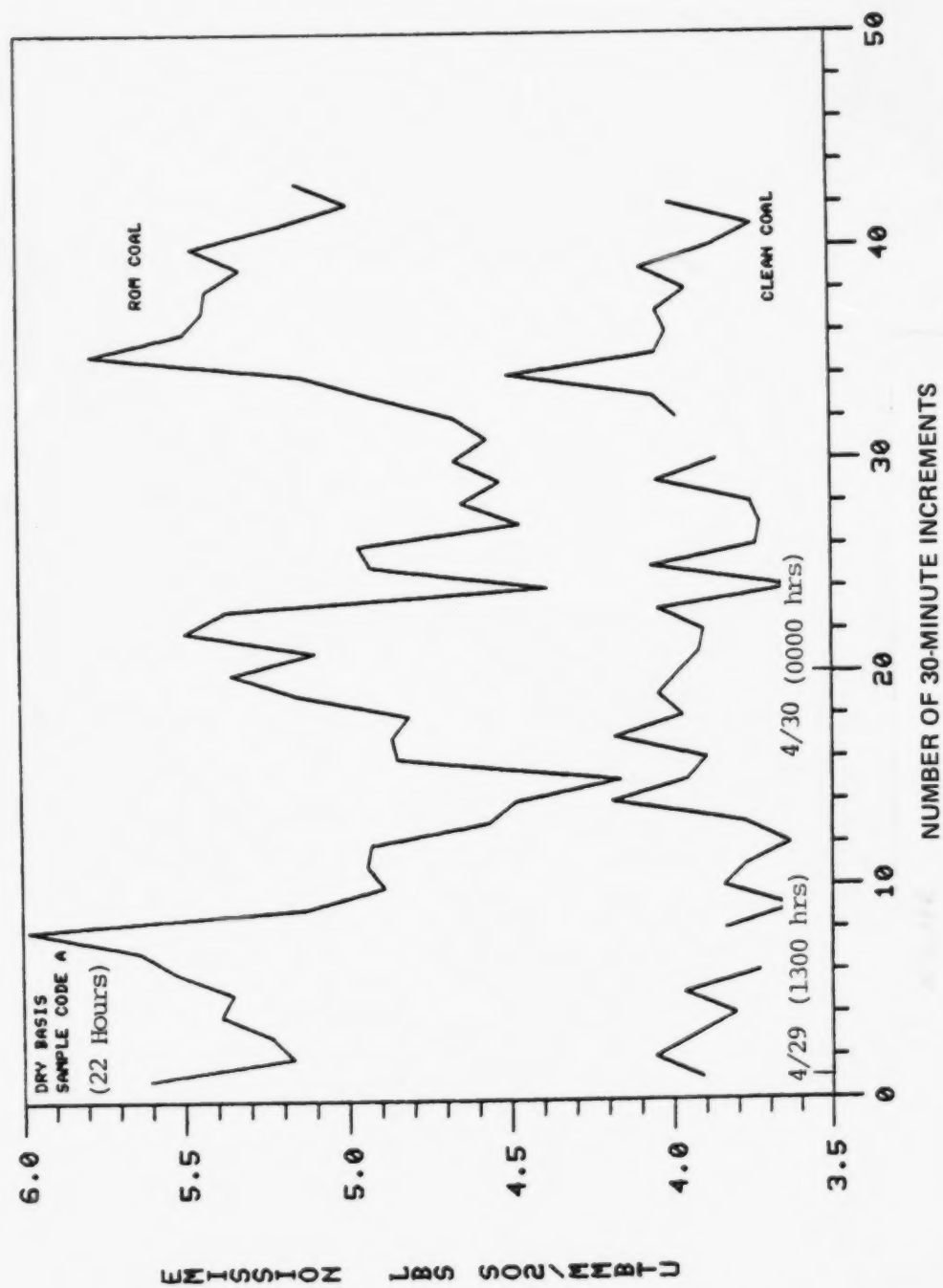


Figure 5-5. R&F Coal Company - 30-minute increment data for sulfur dioxide emission rate.

TABLE 5-1. R&F COAL COMPANY - 22-HOUR INTENSIVE STUDY (A) SAMPLED AT 30-MINUTE INCREMENTS

ROM COAL STATISTICAL SUMMARY									
	MEAN*	VARIANCE†	STANDARD DEVIATION*	RSD	ANALYSIS VARIANCE †	ANALYSIS STANDARD DEVIATION*	ANALYSIS RSD		
	$\bar{x}$	S^2	S	$S/\bar{x}$	S^2	S_a	$S_a/\bar{x}$		
Total Sulfur	2.822	0.045	0.212	0.075	0.004	0.065	0.023		
Pyritic Sulfur	1.578	0.063	0.252	0.160	0.012	0.110	0.070		
Organic Sulfur	1.244	0.035	0.187	0.150	NA	NA	NA		
Heating Value	11,117	23,167	152.21	0.014	4,972	70.52	0.006		
Ash Content	20.592	4.827	2.197	0.107	0.031	0.175	0.009		
Total Moisture	6.994	0.923	0.961	0.137	0.010	0.098	0.014		
Emission Rate	5.073	0.163	0.403	0.080	NA	NA	NA		
CLEAN COAL STATISTICAL SUMMARY									
Total Sulfur	2.390	0.011	0.106	0.044	0.004	0.062	0.026		
Pyritic Sulfur	1.239	0.015	0.124	0.100	0.005	0.069	0.056		
Organic Sulfur	1.151	0.029	0.169	0.147	NA	NA	NA		
Heating Value	12,156	47,293	217.47	0.018	6,001	77.46	0.006		
Ash Content	14.076	0.850	0.922	0.066	0.024	0.156	0.011		
Total Moisture	7.917	6.648	2.578	0.326	0.013	0.112	0.014		
Emission Rate	3.928	0.029	0.169	0.043	NA	NA	NA		

* Units are weight % for sulfur, ash and moisture, Btu/lb for heating value, and lb SO₂/10⁶ Btu for emission rate.

† Units are weight %² for sulfur, ash and moisture, (Btu/lb)² for heating value, and (lb SO₂/10⁶ Btu)² for emission rate.

NA: S_a not applicable because organic sulfur and emission rate were not directly measured.

30-Minute Incremental Data for 40 Hours (Studies B & C)

Figures 5-6 through 5-9 plot the raw data for this intensive study, and Figure 5-10 illustrates the corresponding emission rate data. A statistical summary of this data set is presented in Table 5-2. The results of duplicate analysis are tabulated in Appendix A, Section A.2.

The following changes in each of these parameters between the feed and clean coals were found:

<u>Parameter</u>	<u>Percent Change in $\bar{x}$</u>
Total Sulfur	- 15
Pyritic Sulfur	- 33
Organic Sulfur	+ 13
Heating Value	+ 10
Ash Content	- 39
Emission Rate	- 23

Although the average coal characteristics differed between intensive studies A and B, the percent changes indicate nearly identical cleaning results. Also seen in Table 5-2, the reduction in variance is pronounced for every parameter except organic sulfur.

8-Hour Composite Data

The analysis of 8-hour composite samples is illustrated on Figures 5-11 through 5-14 for sulfur, heating value, and ash, and on Figure 5-15 for emission rate. The gaps in the plotted lines for each figure (not to scale) indicate the periods of time the automatic sampling systems were not operational over the seven-week study, although the plant was processing coal. The following percent changes were found:

<u>Parameter</u>	<u>Percent Change in $\bar{x}$</u>
Total Sulfur	- 17
Pyritic Sulfur	- 29
Organic Sulfur	- 1
Heating Value	+ 12
Ash Content	- 41
Emission Rate	- 26

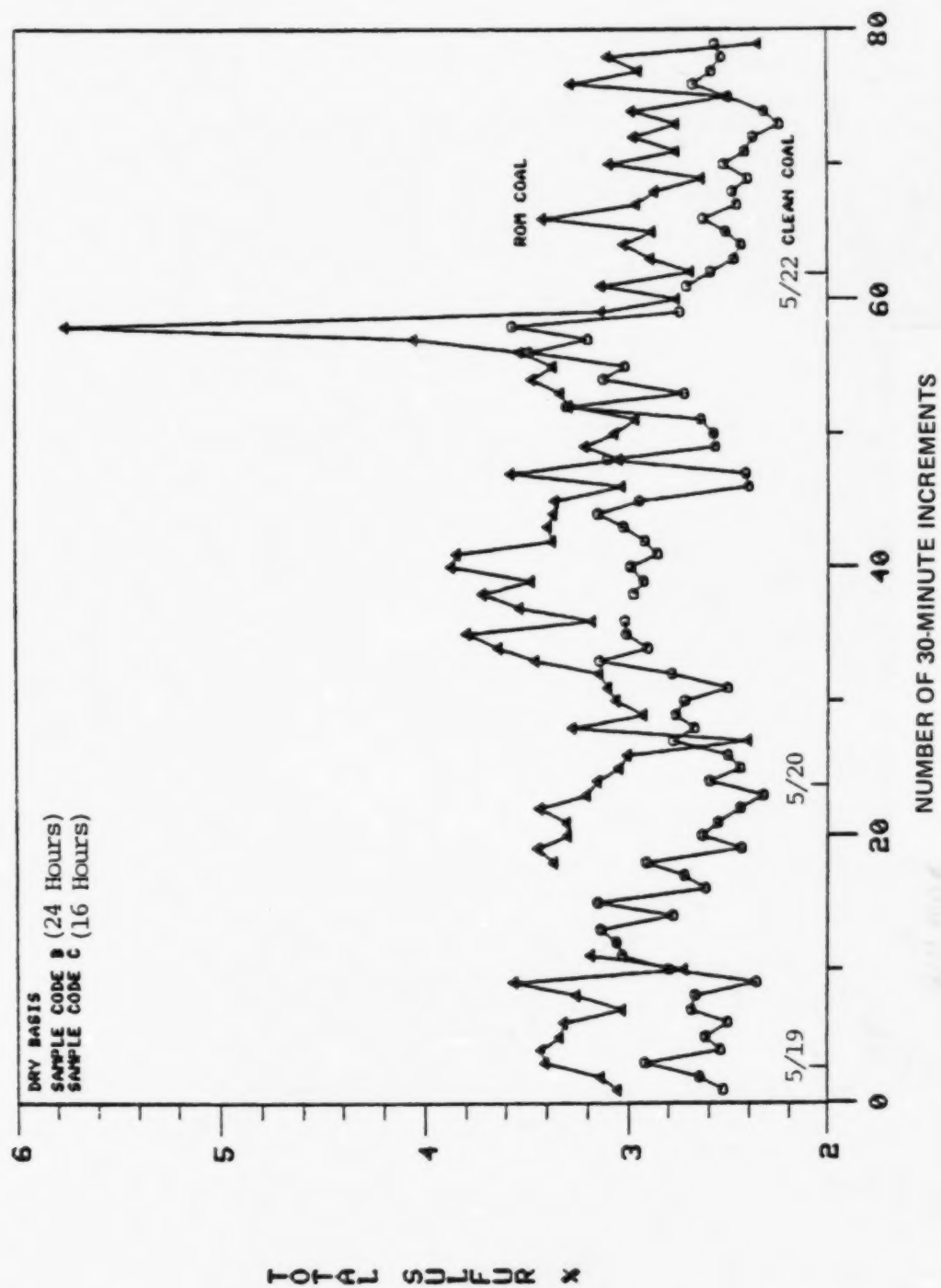


Figure 5-6. R&F Coal Company - 30-minute increment data for total sulfur.

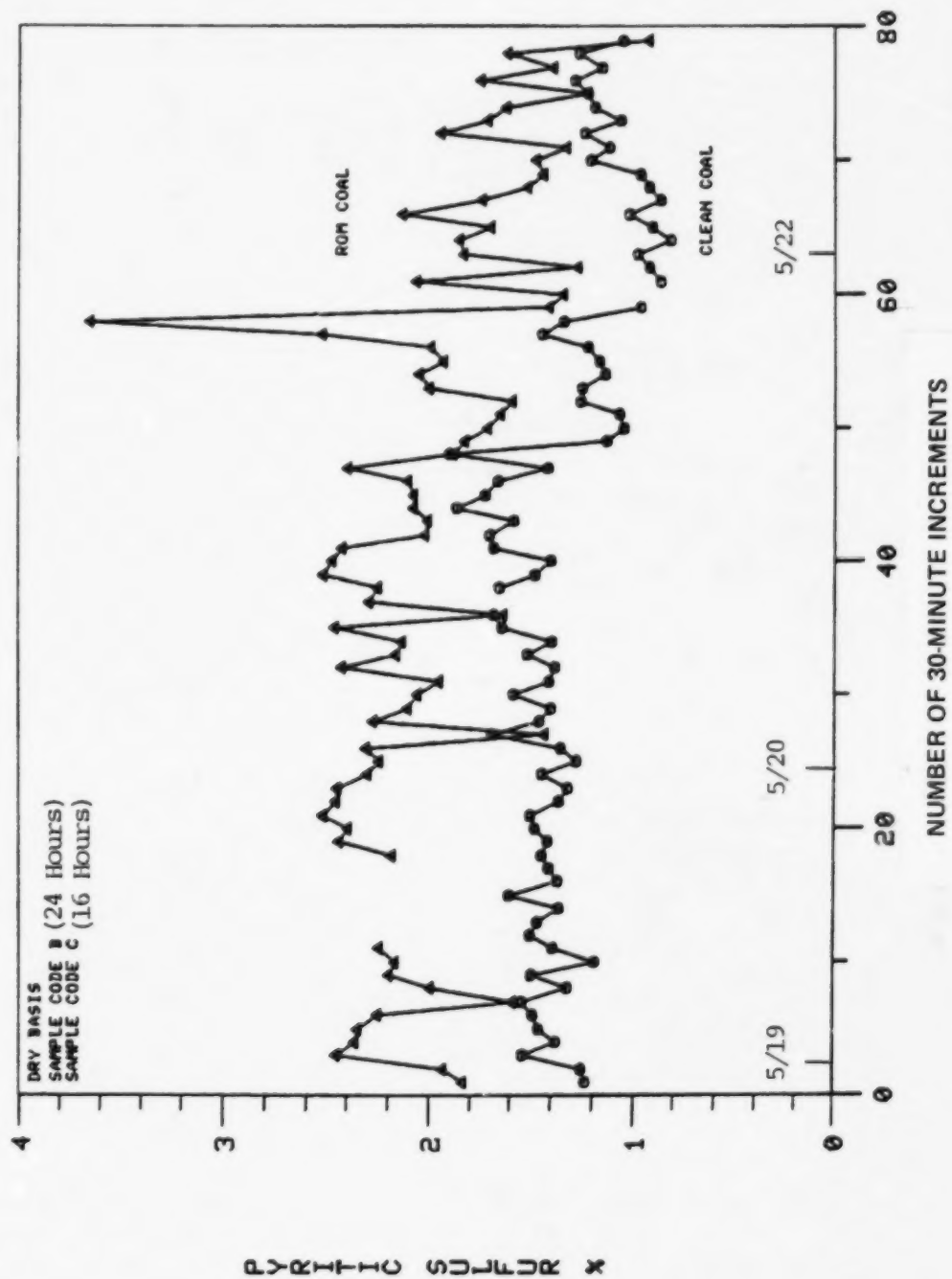


Figure 5-7. R&F Coal Company - 30-minute increment data for pyritic sulfur.

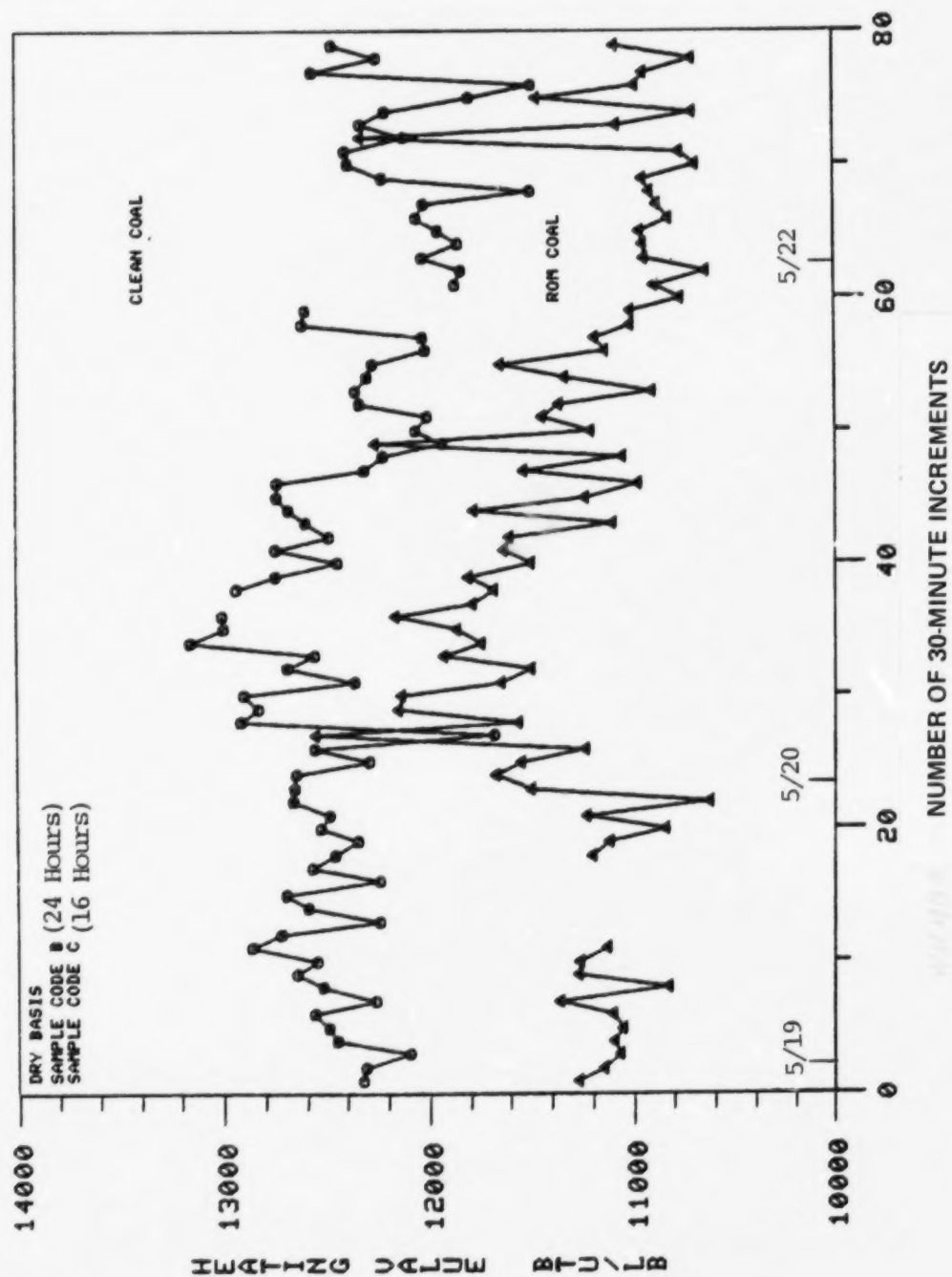


Figure 5-8. R&F Coal Company - 30-minute increment data for heating value.

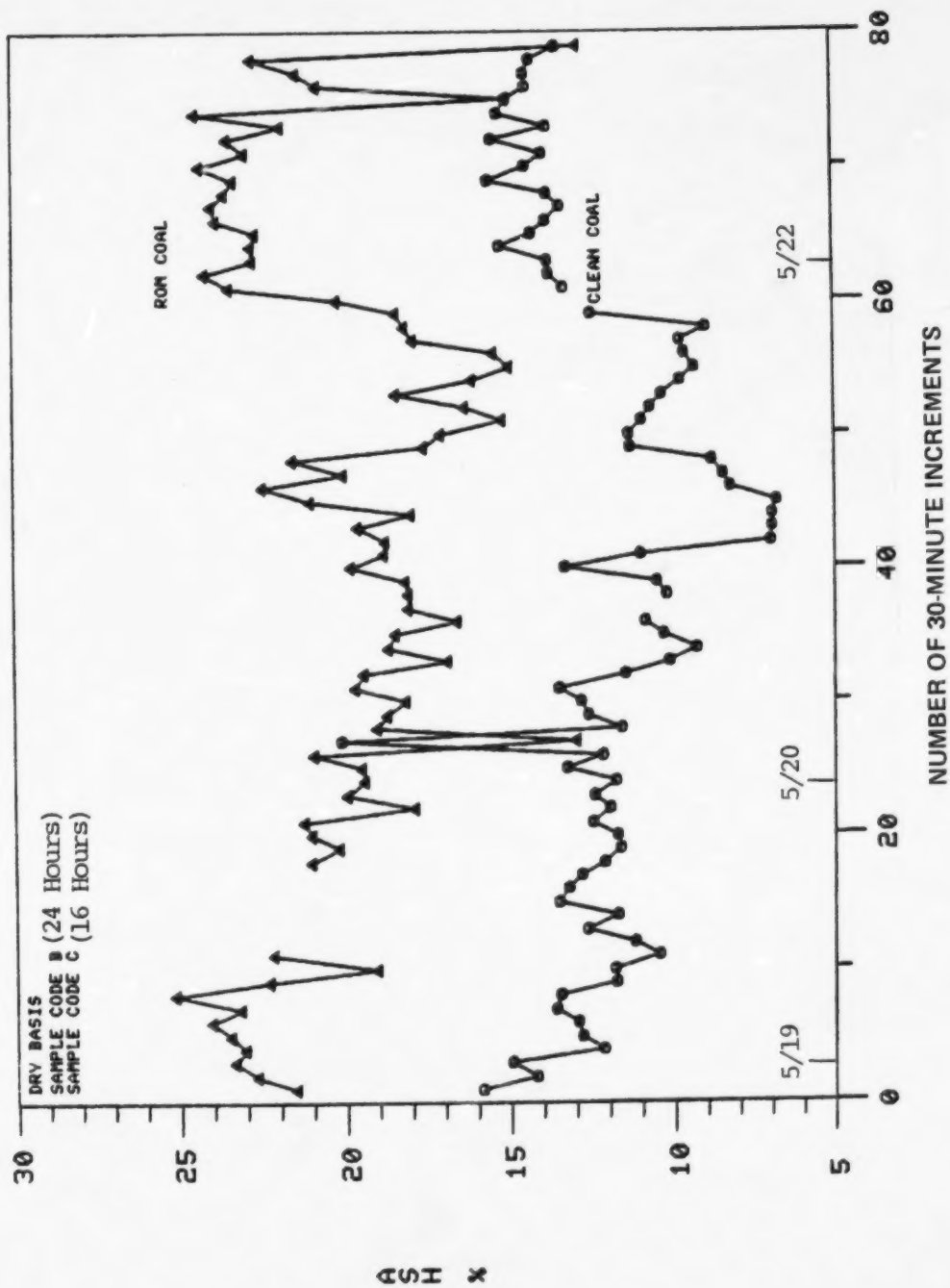


Figure 5-9. R&F Coal Company - 30-minute increment data for ash content.

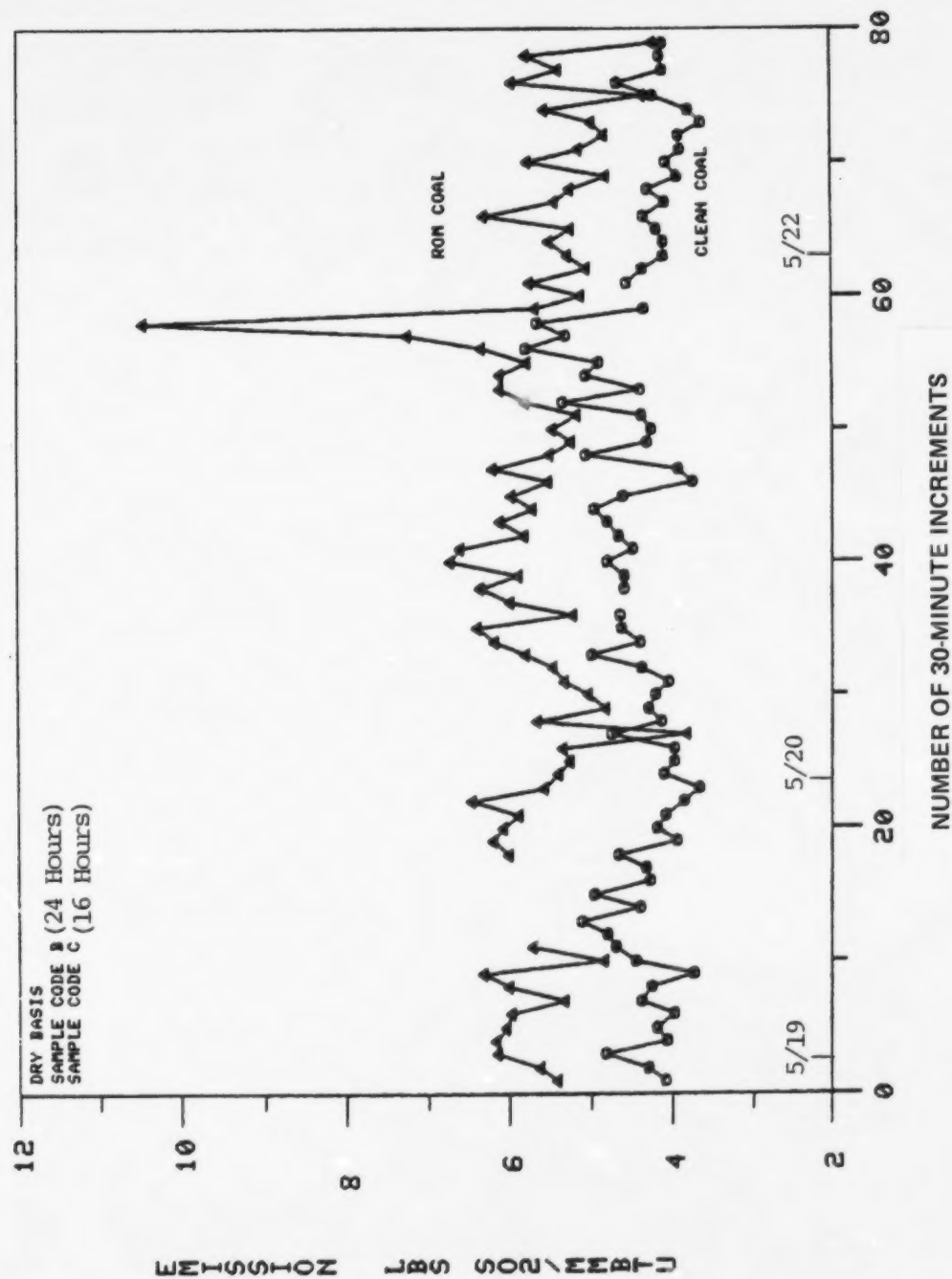


Figure 5-10. R&F Coal Company - 30-minute increment data for sulfur dioxide emission rate.

TABLE 5-2. R&F COAL COMPANY - 40-HOUR INTENSIVE STUDY (B&C) SAMPLED AT 30-MINUTE INCREMENTS

ROM COAL STATISTICAL SUMMARY									
	MEAN*	VARIANCE†	STANDARD DEVIATION*	RSD	ANALYSIS VARIANCE †	ANALYSIS STANDARD DEVIATION*	ANALYSIS RSD		
	$\bar{x}$	s^2	s	$s/\bar{x}$	s^2	s_a	$s_a/\bar{x}$		
Total Sulfur	3.227	0.196	0.442	0.137	0.003	0.052	0.016		
Pyritic Sulfur	1.999	0.176	0.420	0.210	0.015	0.124	0.062		
Organic Sulfur	1.228	0.075	0.274	0.223	NA	NA	NA		
Heating Value	11,296	188,185	433.80	0.038	9,840	99.19	0.009		
Ash Content	20.146	8.235	2.870	0.142	0.034	0.186	0.009		
Total Moisture	7.316	1.276	1.130	0.154	0.010	0.102	0.014		
Emission Rate	5.713	0.643	0.802	0.140	NA	NA	NA		
CLEAN COAL STATISTICAL SUMMARY									
Total Sulfur	2.729	0.079	0.281	0.103	0.004	0.066	0.024		
Pyritic Sulfur	1.339	0.060	0.245	0.183	0.008	0.090	0.067		
Organic Sulfur	1.390	0.081	0.285	0.205	NA	NA	NA		
Heating Value	12,395	118,957	344.90	0.028	8,089	89.94	0.007		
Ash Content	12.190	5.464	2.338	0.192	0.052	0.229	0.019		
Total Moisture	6.714	2.832	1.683	0.251	0.025	0.158	0.023		
Emission Rate	4.399	0.195	0.441	0.100	NA	NA	NA		

* Units are weight % for sulfur, ash and moisture, Btu/lb for heating value, and lb SO₂/10⁶ Btu for emission rate.† Units are weight %² for sulfur, ash and moisture, (Btu/lb)² for heating value, and (lb SO₂/10⁶ Btu)² for emission rate.NA: s_a not applicable because organic sulfur and emission rate were not directly measured.

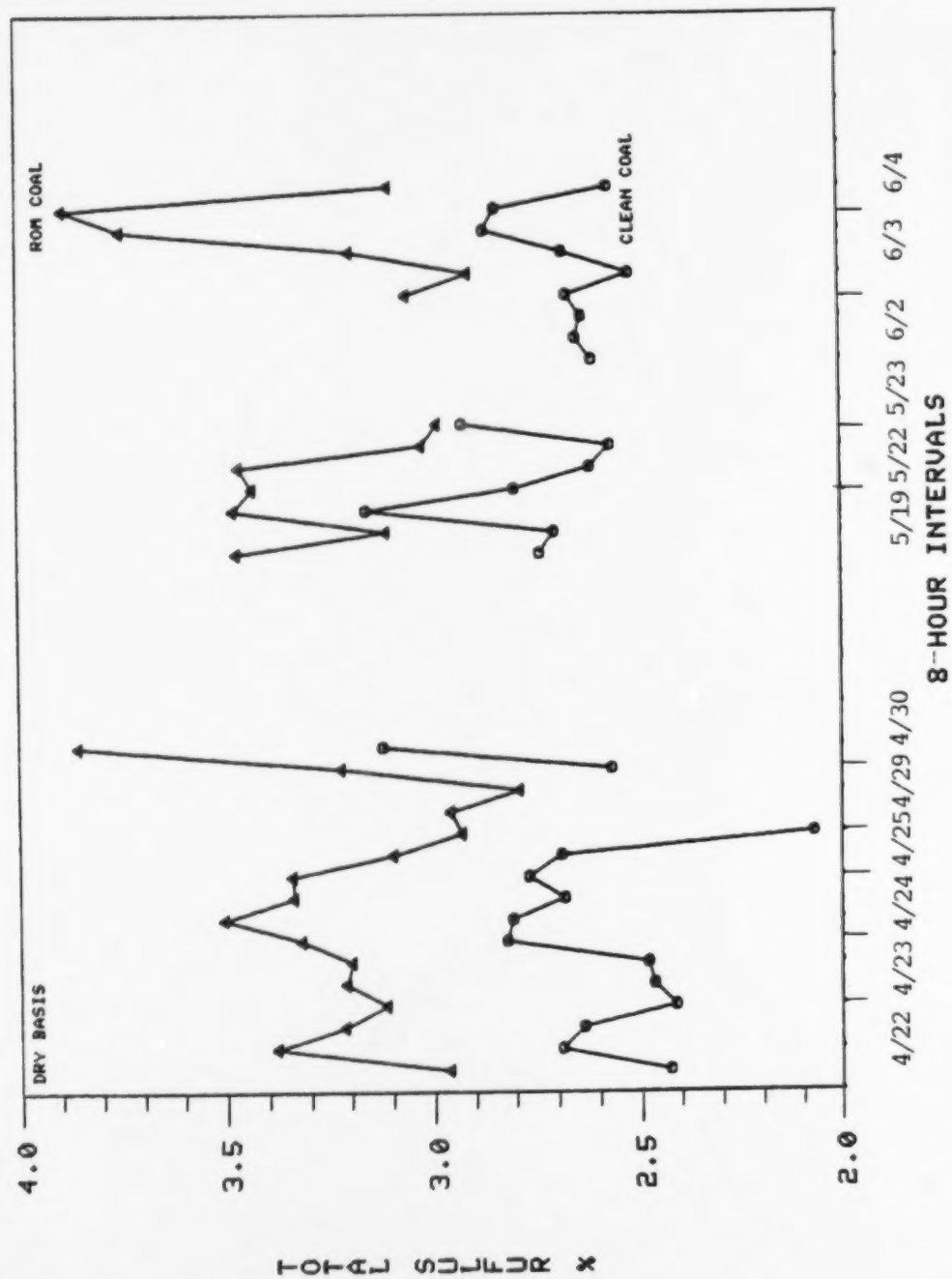


Figure 5-11. R&F Coal Company - 8-hour composite data for total sulfur.

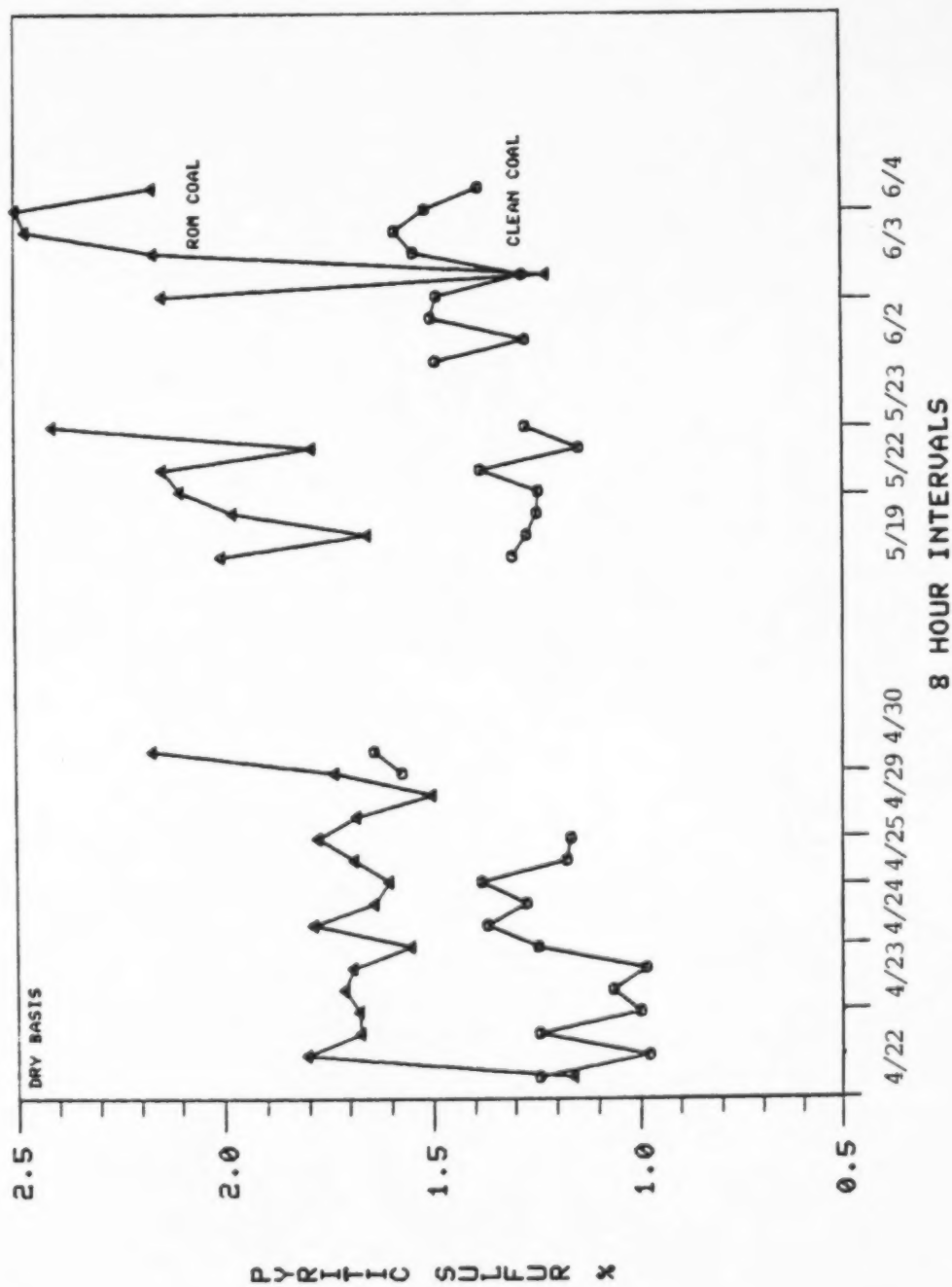
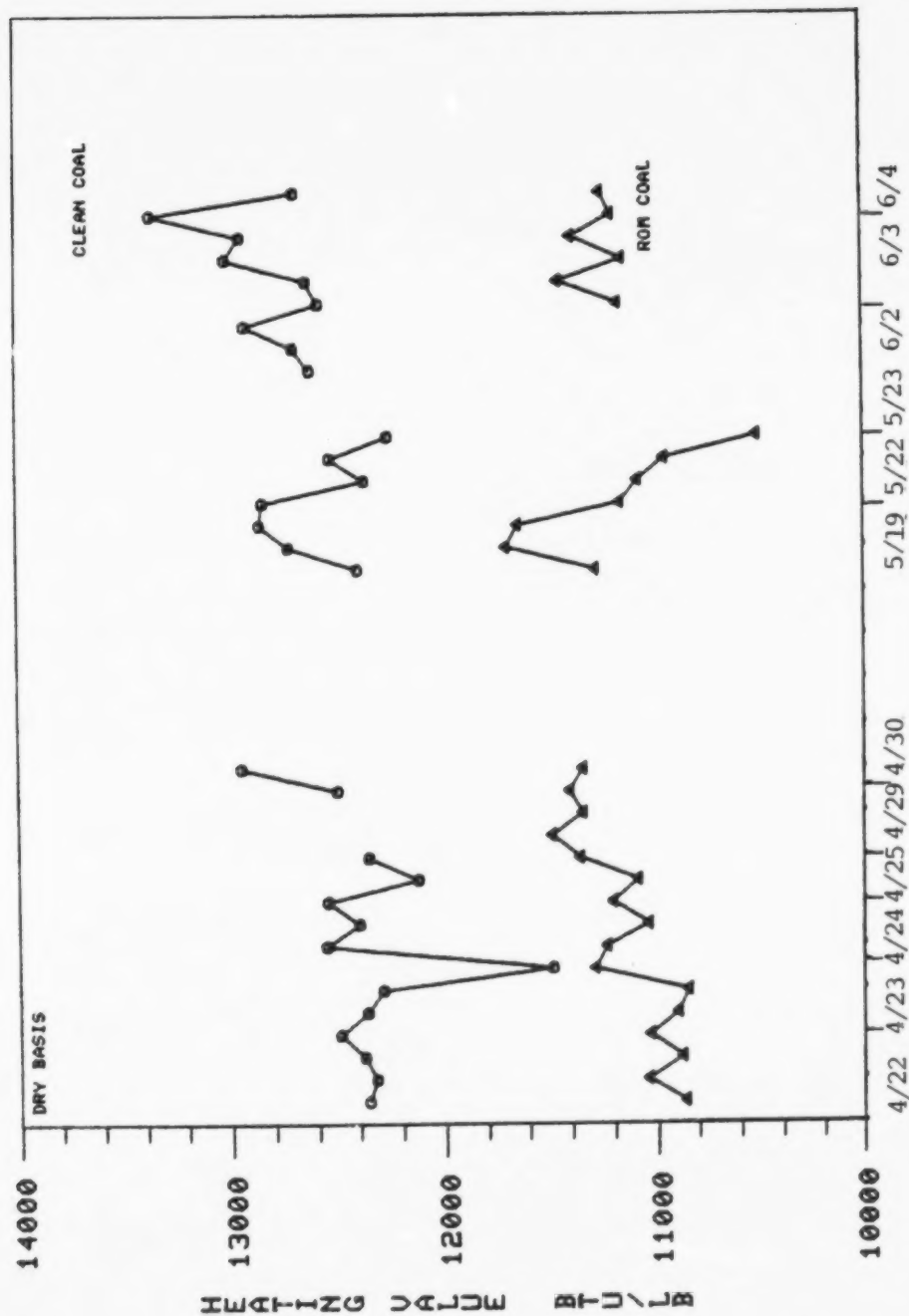


Figure 5-12. R&F Coal Company - 8-hour composite data for pyritic sulfur.



8-HOUR INTERVALS

Figure 5-13. R&F Coal Company - 8-hour composite data for heating value.

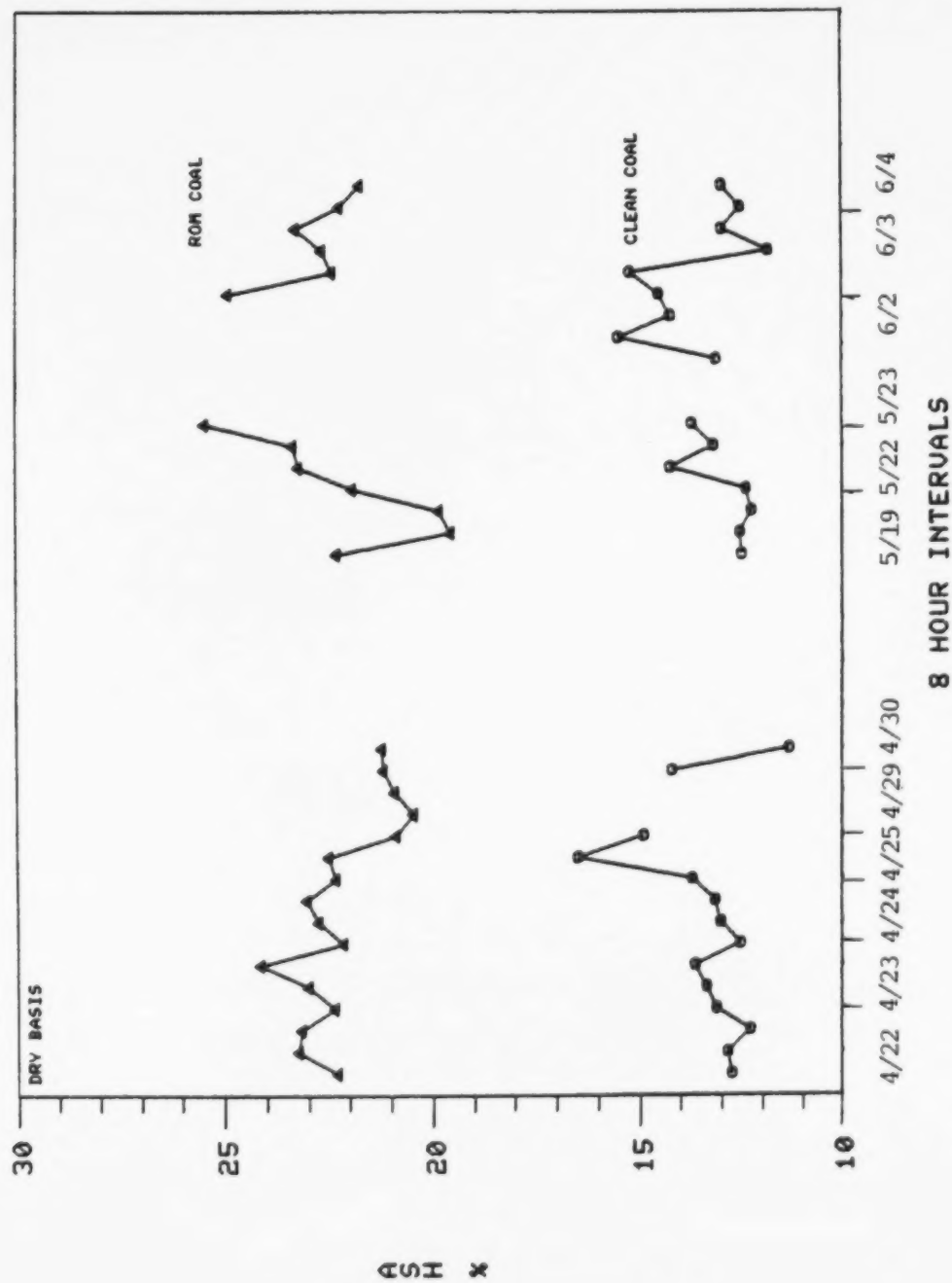
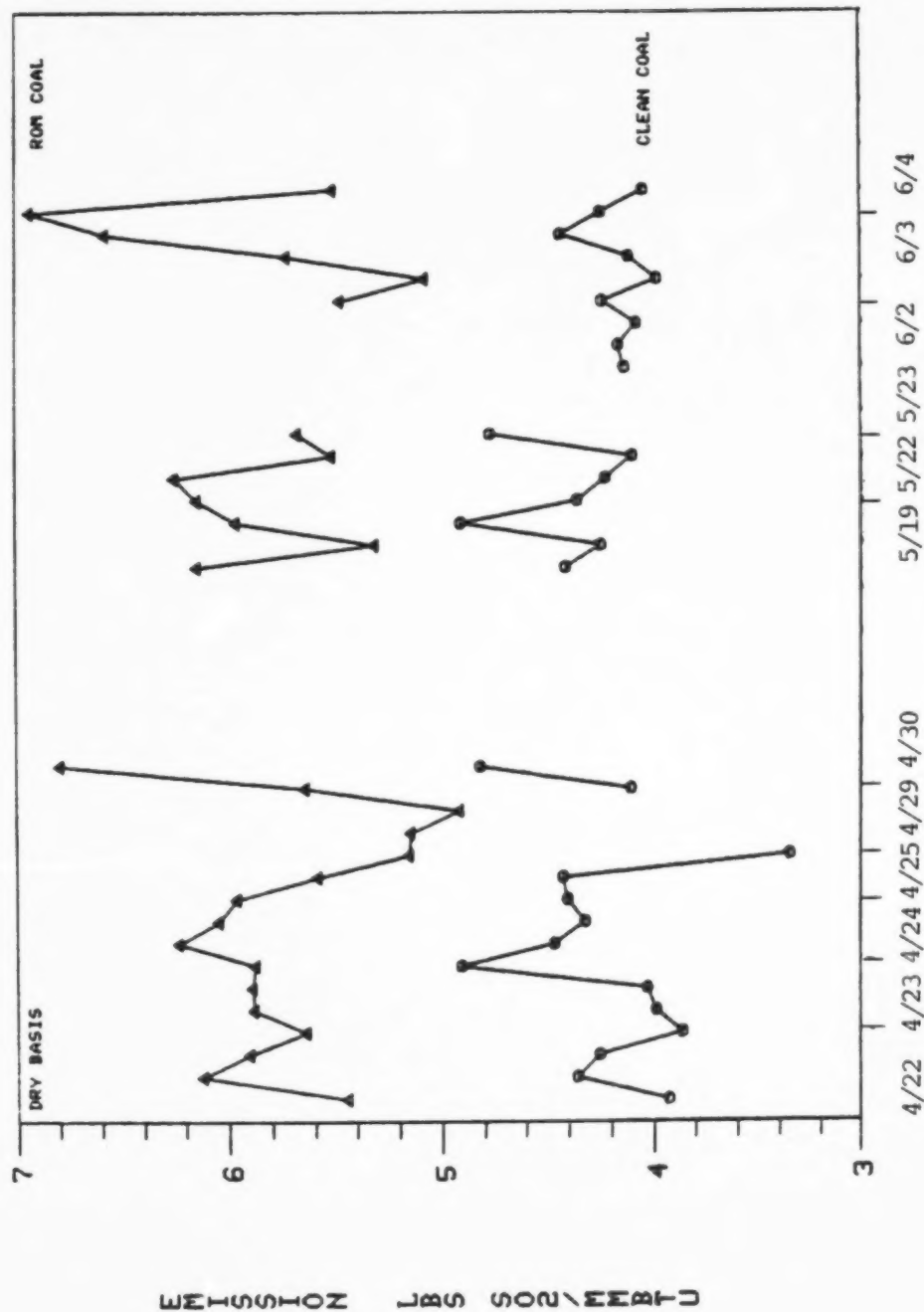


Figure 5-14. R&F Coal Company - 8-hour composite data for ash content.



8-HOUR INTERVALS

Figure 5-15. R&F Coal Company - 8-hour composite data for sulfur dioxide emission rate.

The magnitude of the raw and clean coal variances is not as great as those seen during the intensive studies, but this is expected because compositing dampens the variability. Again, a reduction in variance exists for all parameters except organic sulfur and heating value.

Daily, Weekly, and Monthly Composite Data

Figures 5-16 through 5-20 illustrate the daily, weekly and monthly composite data including the calculation of the emission rate for feed and clean coal samples collected at the R & F Coal Company. Every 8 hours, or during the intensive studies, every 30 minutes, ROM and clean coal samples were collected. The gaps between data sets indicate periods of time when the sampling systems were not operating or when there were less than three 8-hour composites to produce one daily composite. Table 5-3 also presents the statistical summary of the results from each one of these individual analytical samples. The duplicate analytical results for the daily, weekly, and monthly composites are tabulated in Appendix A, Section A.4.

The figures indicate the shortcomings in preparing physical composite samples. The results of the raw coal monthly composite often fall outside the analytical range of daily composites, indicating that a true measure of the monthly mean is difficult to obtain from a physical composite. It is expected that mathematical compositing provides a closer estimate of the true monthly mean. These results illustrate the importance of collecting and analyzing samples over relatively short periods of time, 30 minutes to an hour, as opposed to compositing samples for daily or weekly periods. The daily composites do provide information on larger lot sizes but sacrifice the resolution required to adequately model the coal characteristics.

R & F Coal Company In-House Analysis

During the study periods April 22 through June 6, 1980, R & F Coal Company routinely collected and analyzed clean coal samples at 30-minute intervals for quality control characterization of the product. These data are illustrated on Figures 5-21 through 5-23. The gaps in each line plot indicate periods when samples were not collected but when the plant was

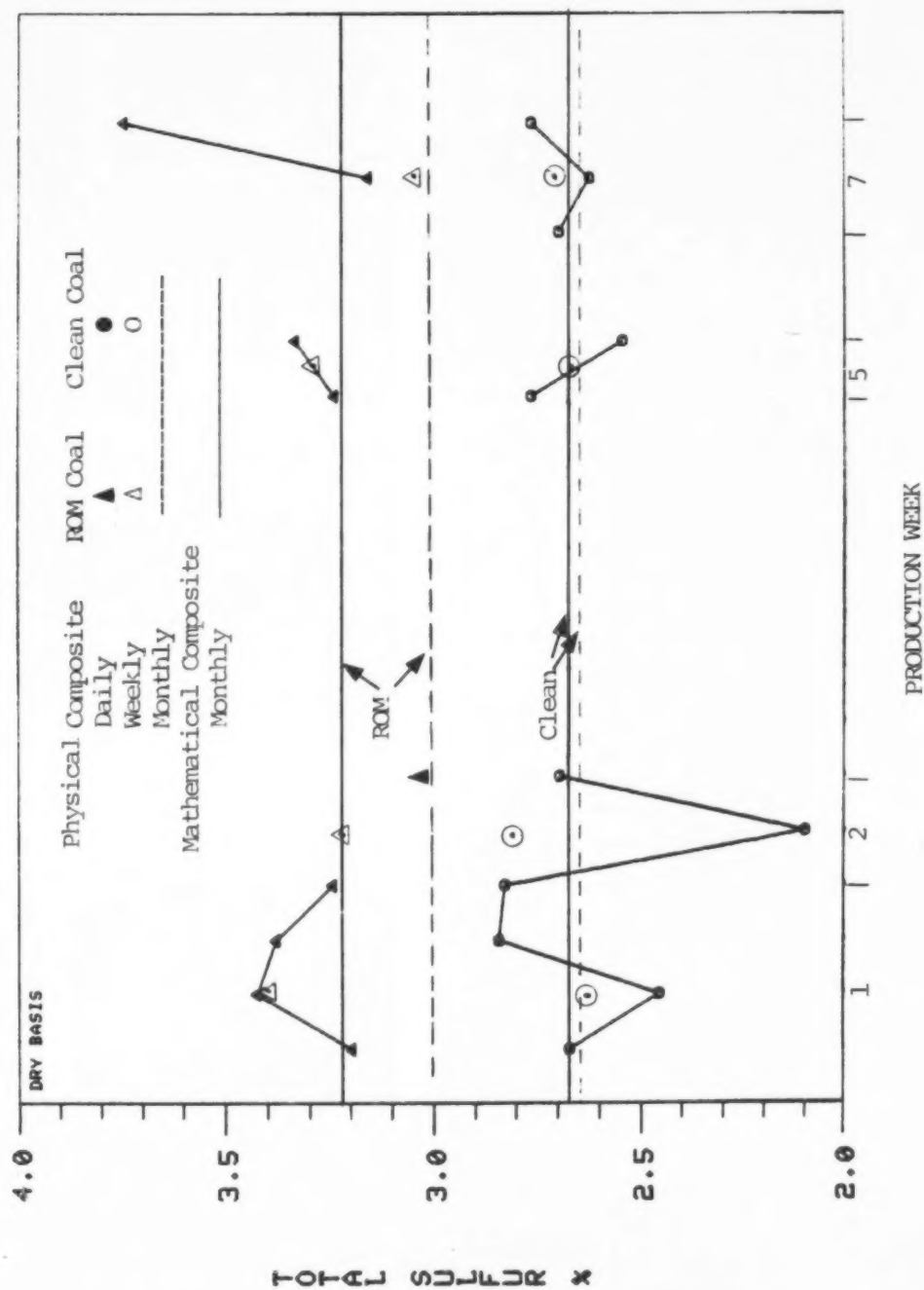


Figure 5-16. R&F Coal Company - daily, weekly, monthly composite data for total sulfur.

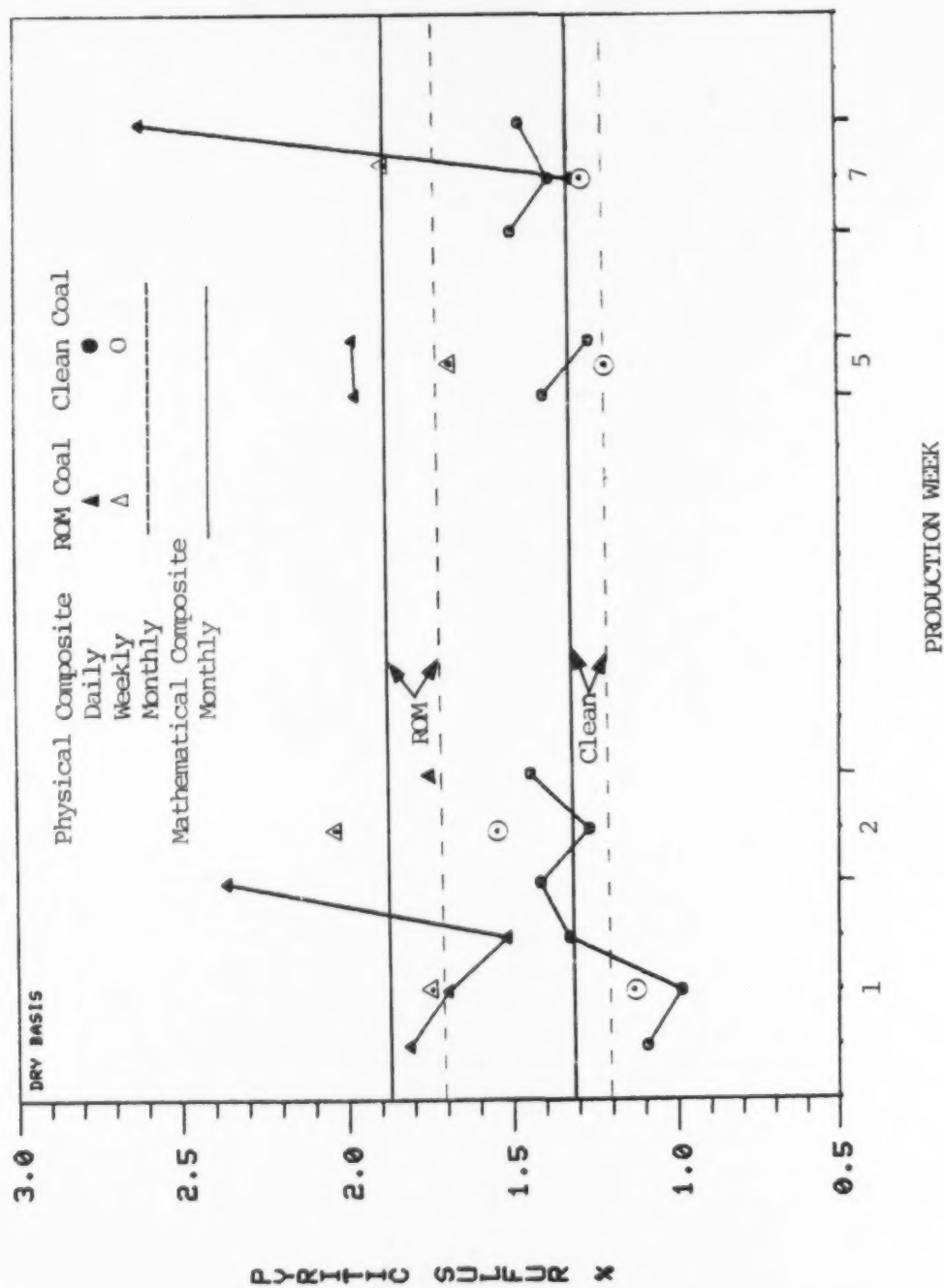


Figure 5-17. R&F Coal Company - daily, weekly, monthly composite data for pyritic sulfur.

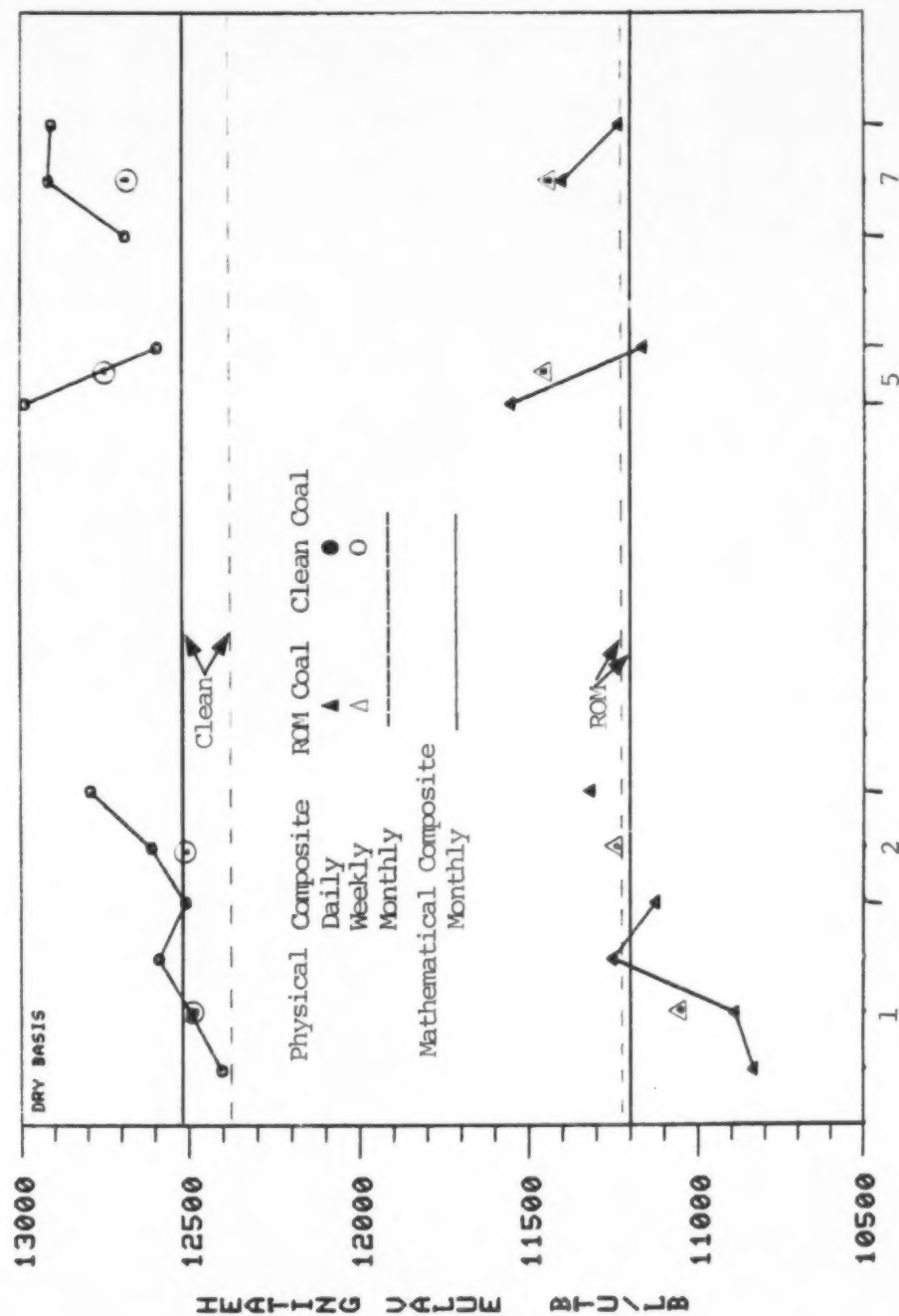


Figure 5-18. R&F Coal Company - daily, weekly, monthly composites for heating value.

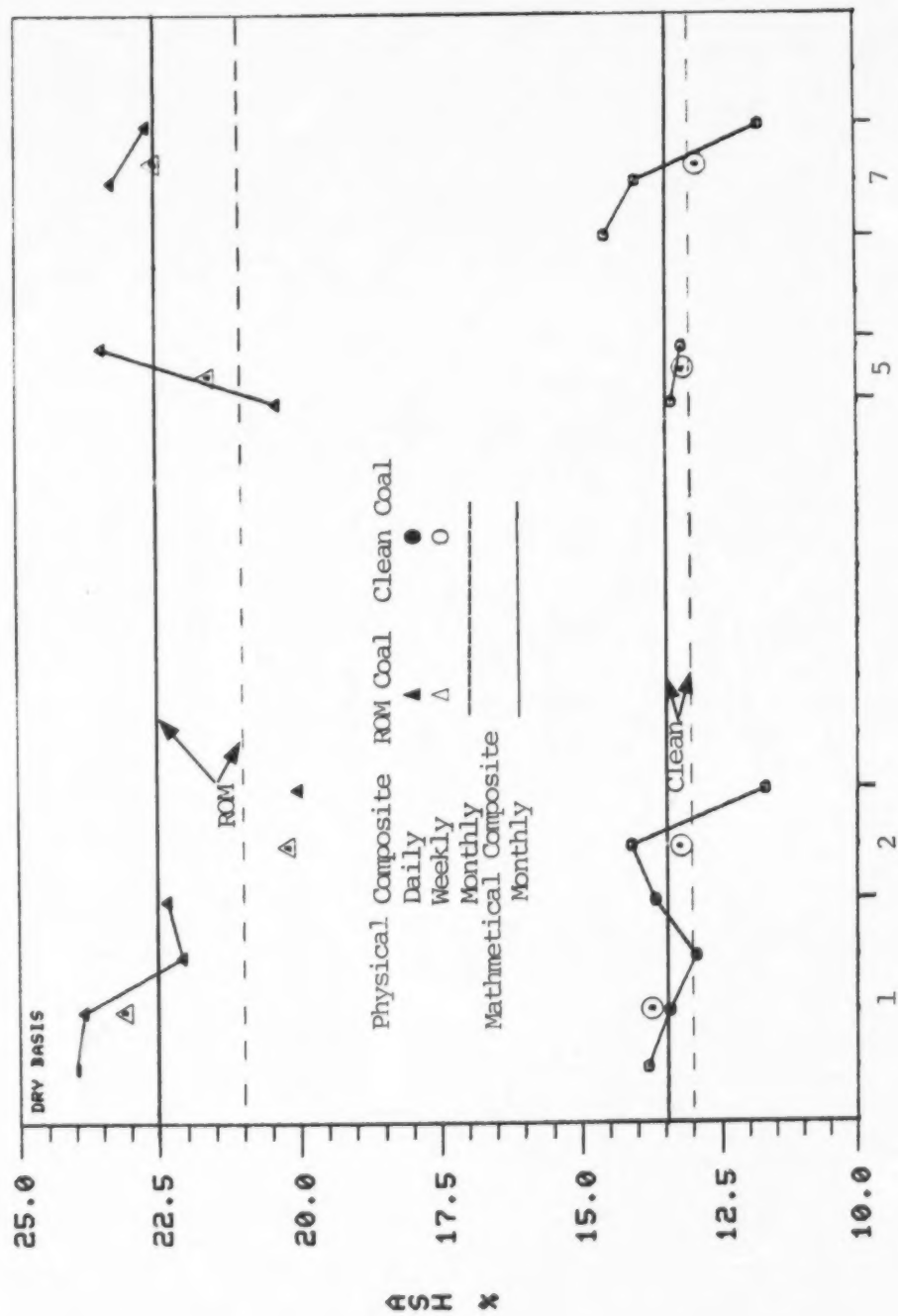


Figure 5-19. R&F Coal Company - daily, weekly, monthly composites for ash content.

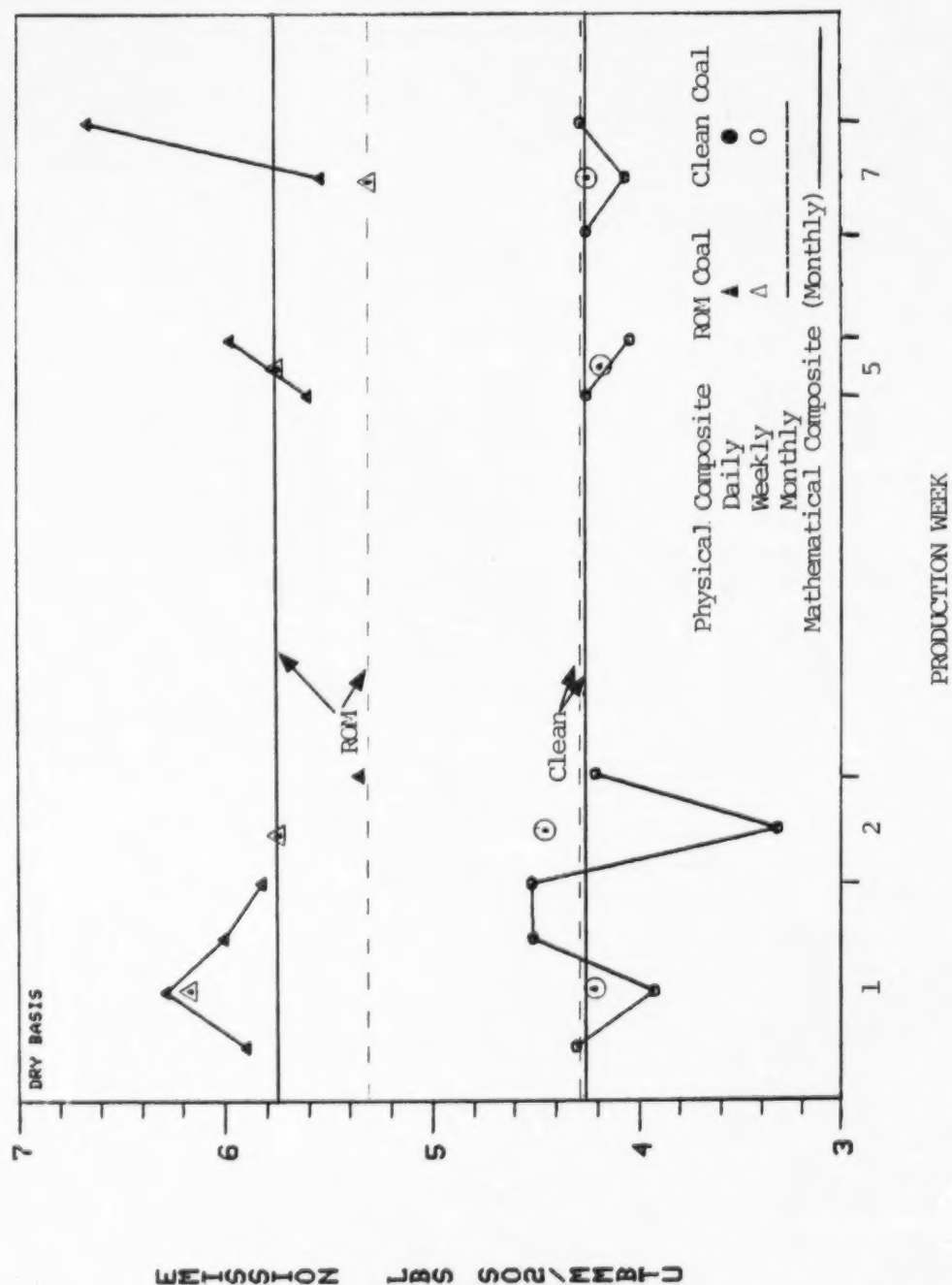


Figure 5-20. R&F Coal Company - daily, weekly, monthly composites for sulfur dioxide emission rate.

TABLE 5-3. R&F COAL COMPANY - 8-HOUR COMPOSITE DATA

ROM COAL STATISTICAL SUMMARY

	MEAN*	VARIANCE†		STANDARD DEVIATION*	RSD	ANALYSIS VARIANCE †	ANALYSIS STANDARD DEVIATION*		ANALYSIS RSD
		S^2	$\bar{S}^2$				S_a	$S_{a/\bar{x}}$	
Total Sulfur	3.217	0.085	0.291	0.091	0.007	0.086	0.027	0.027	0.027
Pyritic Sulfur	1.860	0.106	0.325	0.175	0.024	0.156	0.084	0.084	0.084
Organic Sulfur	1.357	0.097	0.312	0.230	NA	NA	NA	NA	NA
Heating Value	11,189	91405	302.33	0.027	3,196	56.54	0.005	0.005	0.005
Ash Content	22.497	1.914	1.384	0.061	0.065	0.254	0.011	0.011	0.011
Total Moisture	6.297	1.376	1.173	0.186	0.018	0.135	0.021	0.021	0.021
Emission Rate	5.747	0.277	0.526	0.092	NA	NA	NA	NA	NA

CLEAN COAL STATISTICAL SUMMARY

Total Sulfur	2.667	0.042	0.206	0.077	0.002	0.043	0.016	0.016	0.016
Pyritic Sulfur	1.318	0.031	0.177	0.135	0.008	0.087	0.066	0.066	0.066
Organic Sulfur	1.350	0.046	0.215	0.160	NA	NA	NA	NA	NA
Heating Value	12,523	98,531	313.90	0.025	6,512	80.70	0.006	0.006	0.006
Ash Content	13.370	1.227	1.108	0.083	0.039	0.196	0.015	0.015	0.015
Total Moisture	6.202	2.306	1.519	0.245	0.015	0.121	0.020	0.020	0.020
Emission Rate	4.257	0.110	0.331	0.078	NA	NA	NA	NA	NA

* Units are weight % for sulfur, ash and moisture, Btu/lb for heating value, and lb SO₂/10⁶ Btu for emission rate.† Units are weight %² for sulfur, ash and moisture, (Btu/lb)² for heating value, and (lb SO₂/10⁶ Btu)² for emission rate.NA: S_a not applicable because organic sulfur and emission rate were not directly measured.

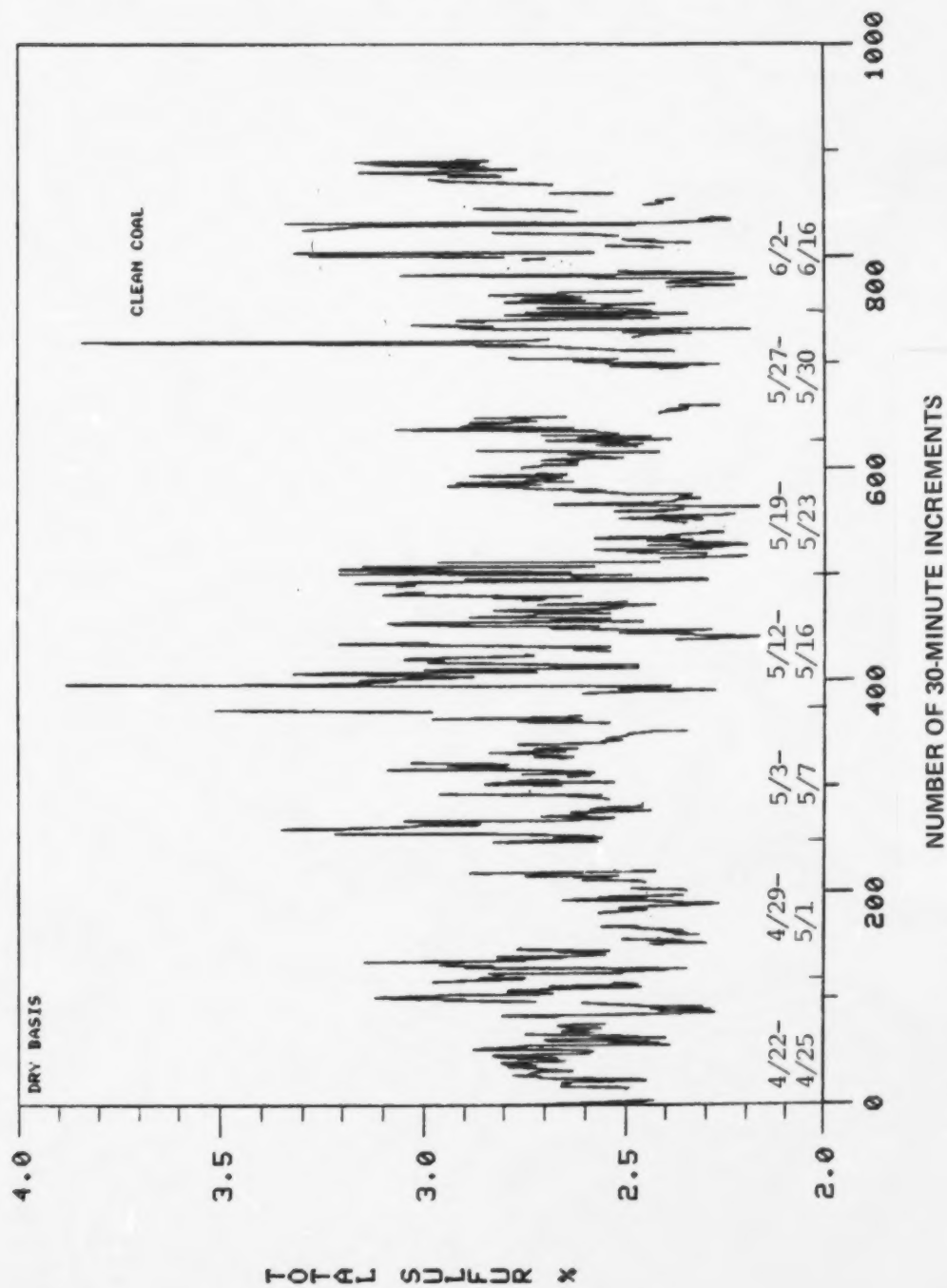


Figure 5-21. R&F Coal Company - measured analytical data for total sulfur.

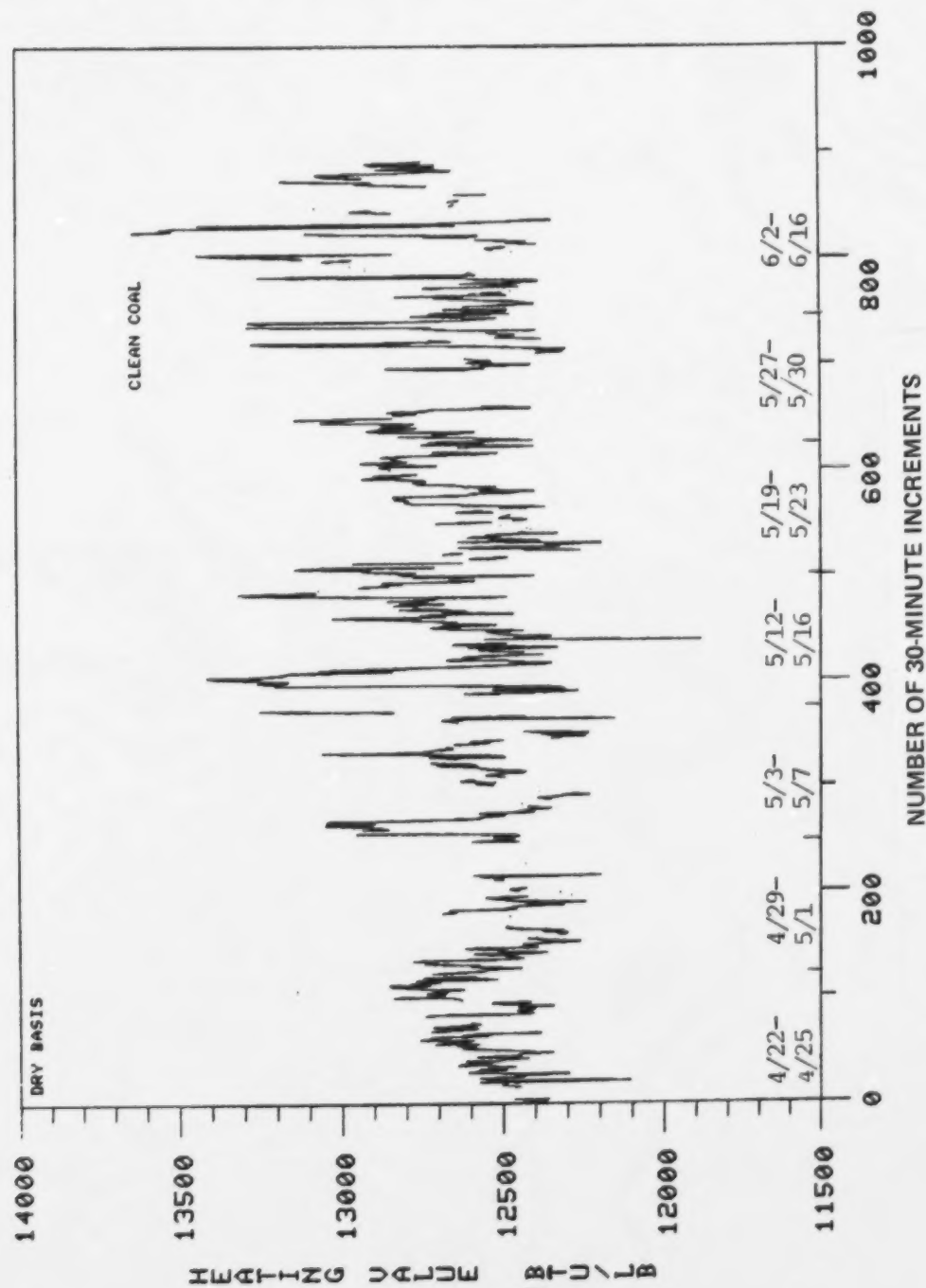


Figure 5-22. R&F Coal Company - measured analytical data for heating value.

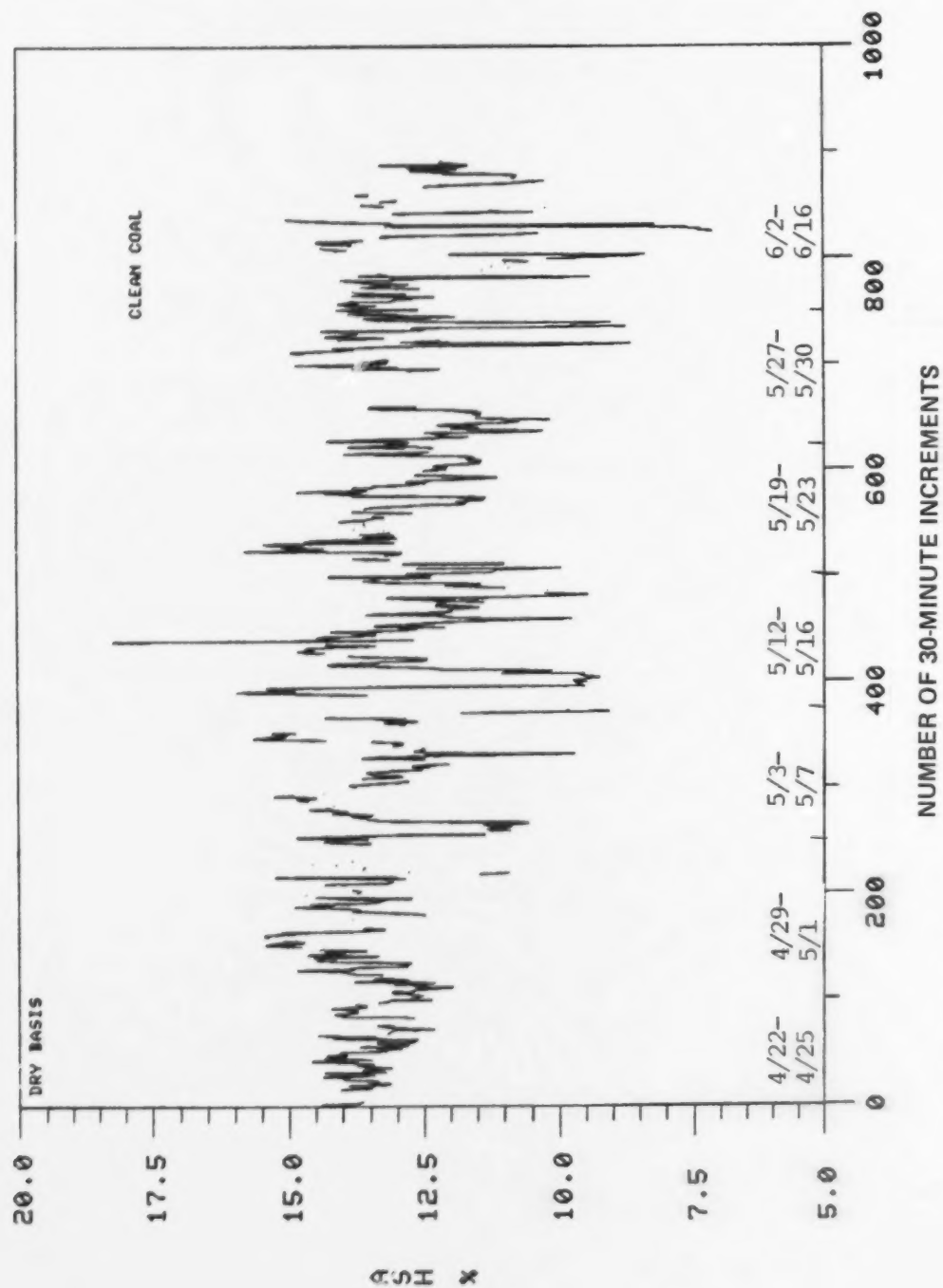


Figure 5-23. R&F Coal Company - measured analytical data for ash content.

running and producing clean coal. A statistical summary of these data is provided on Table 5-4, but because R & F does not routinely analyze raw coal, reduction efficiency data are unavailable.

ANALYSIS OF SAMPLES COLLECTED AT THE REPUBLIC STEEL CORPORATION

From July 21 through August 15, 1980, raw and clean coal samples were collected at the Republic Steel Corporation Kitt Mine No. 1 facility. During this period, hourly samples were collected during the first and fourth weeks, and half-hour samples were collected during the second and third weeks. These grab samples represent cross-stream conveyor cuts taken every 30 or 60 minutes and, because of sampling system limitations, were not time-integrated multiple cuts during these periods of time. Daily, weekly, and monthly composites were prepared from individual splits of each sample collected.

Hourly and Half-Hour Incremental Data

Figures 5-24 through 5-27 illustrate the total sulfur, pyritic sulfur, heating value, and ash characteristics for raw and clean coal samples collected at Republic Steel. Half-hour samples were collected during the period July 28 to August 1 and August 5 to August 8, 1980. Figure 5-28 indicates the sulfur dioxide emission rates for this data set. The data have been statistically summarized two ways: using hourly data for the entire four-week period (Table 5-5) and half-hour data for two weeks (Table 5-6). Comparisons of these summaries indicate they are nearly identical. The results of each duplicate analysis are tabulated in Appendix A, Section A.6.

The statistical summaries and data plots indicate the following changes in parameter values between the raw and clean coal:

<u>Parameter</u>	<u>Percent Change in $\bar{x}$</u>
Total Sulfur	- 49
Pyritic Sulfur	- 64
Organic Sulfur	- 26
Heating Value	+ 38
Ash Content	- 71
Emission Rate	- 63

TABLE 5-4. R&F COAL COMPANY MEASURED DATA

	<u>MEAN</u>	<u>TOTAL VARIANCE</u>	<u>STANDARD DEVIATION</u>	<u>RSD</u>
Ash (%)	12.930	2.110	1.452	.112
Pyritic Sulfur (%)	ND	ND	ND	ND
Organic Sulfur (%)	ND	ND	ND	ND
Total Sulfur (%)	2.648	0.063	0.252	.095
Heating Value (Btu/lb)	12642.	58722.	242.325	.019
Total Moisture (%)	7.251	3.821	1.955	.270
Emission Rate (lbs SO ₂ /MM Btu)	4.184	0.122	0.350	.084

 ND = Not determined.

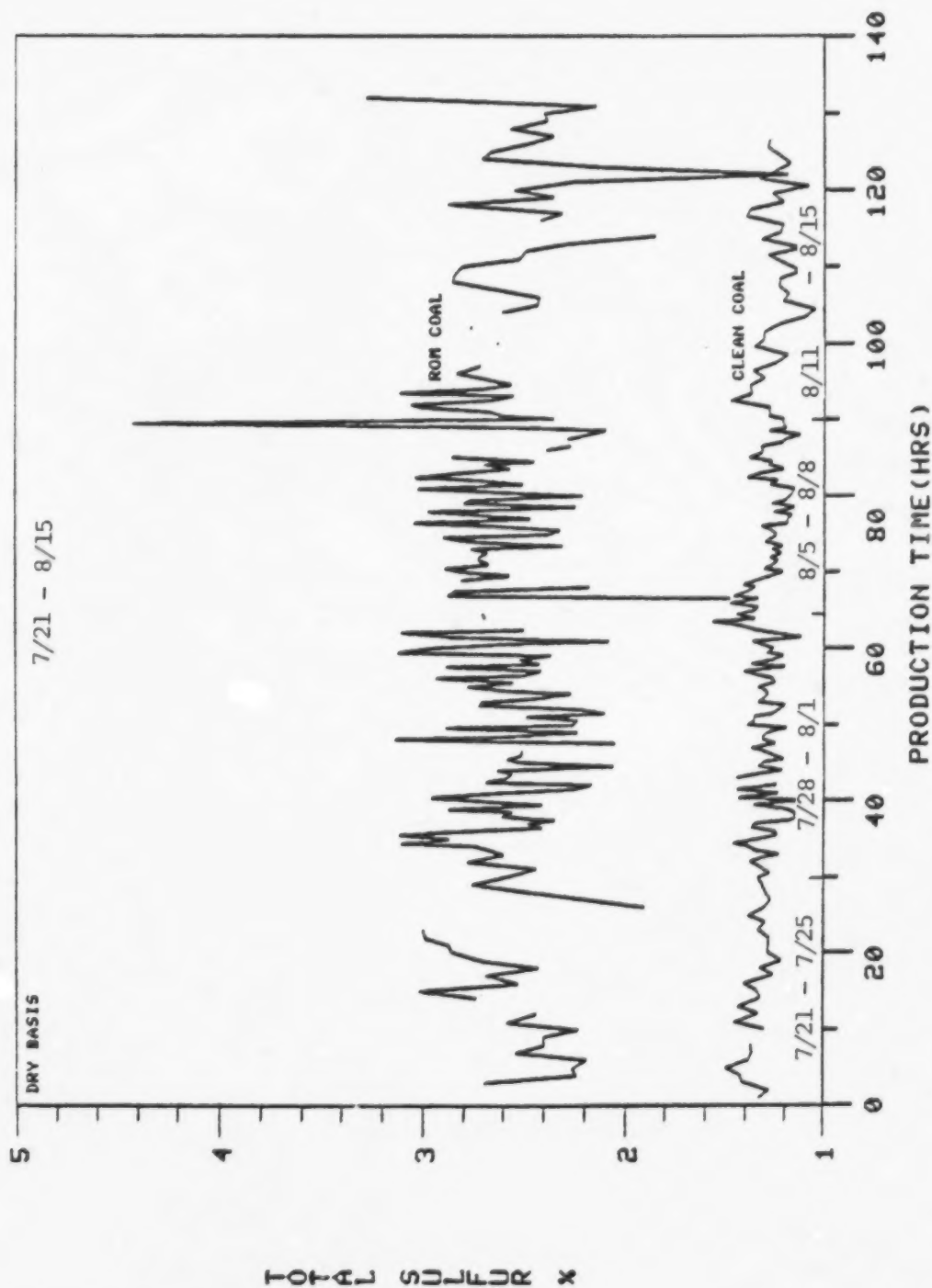


Figure 5-24. Republic Steel Corporation - hourly increment data for total sulfur.

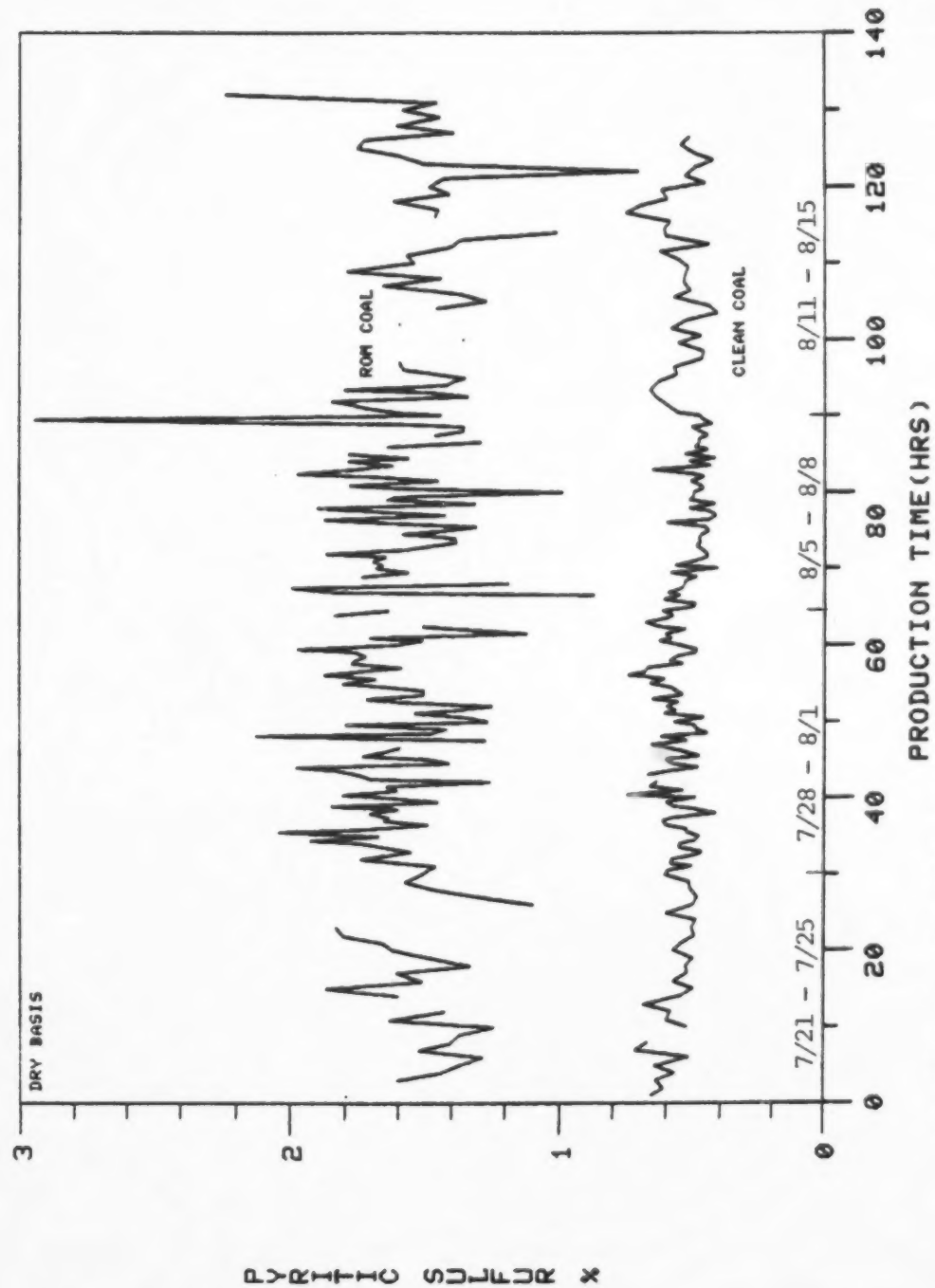


Figure 5-25. Republic Steel Corporation - hourly increment data for pyritic sulfur.

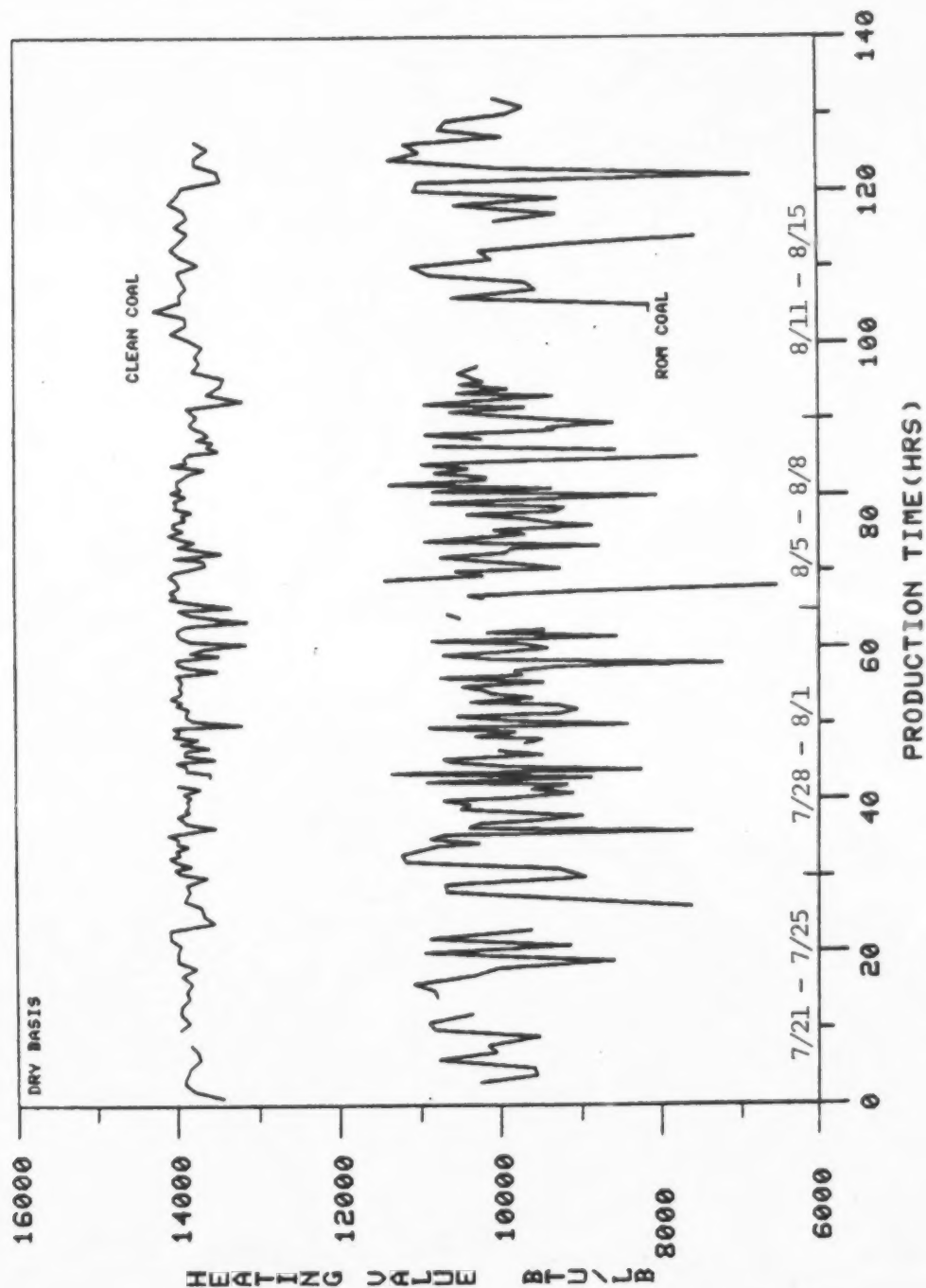


Figure 5-26. Republic Steel Corporation - hourly increment data for heating value.

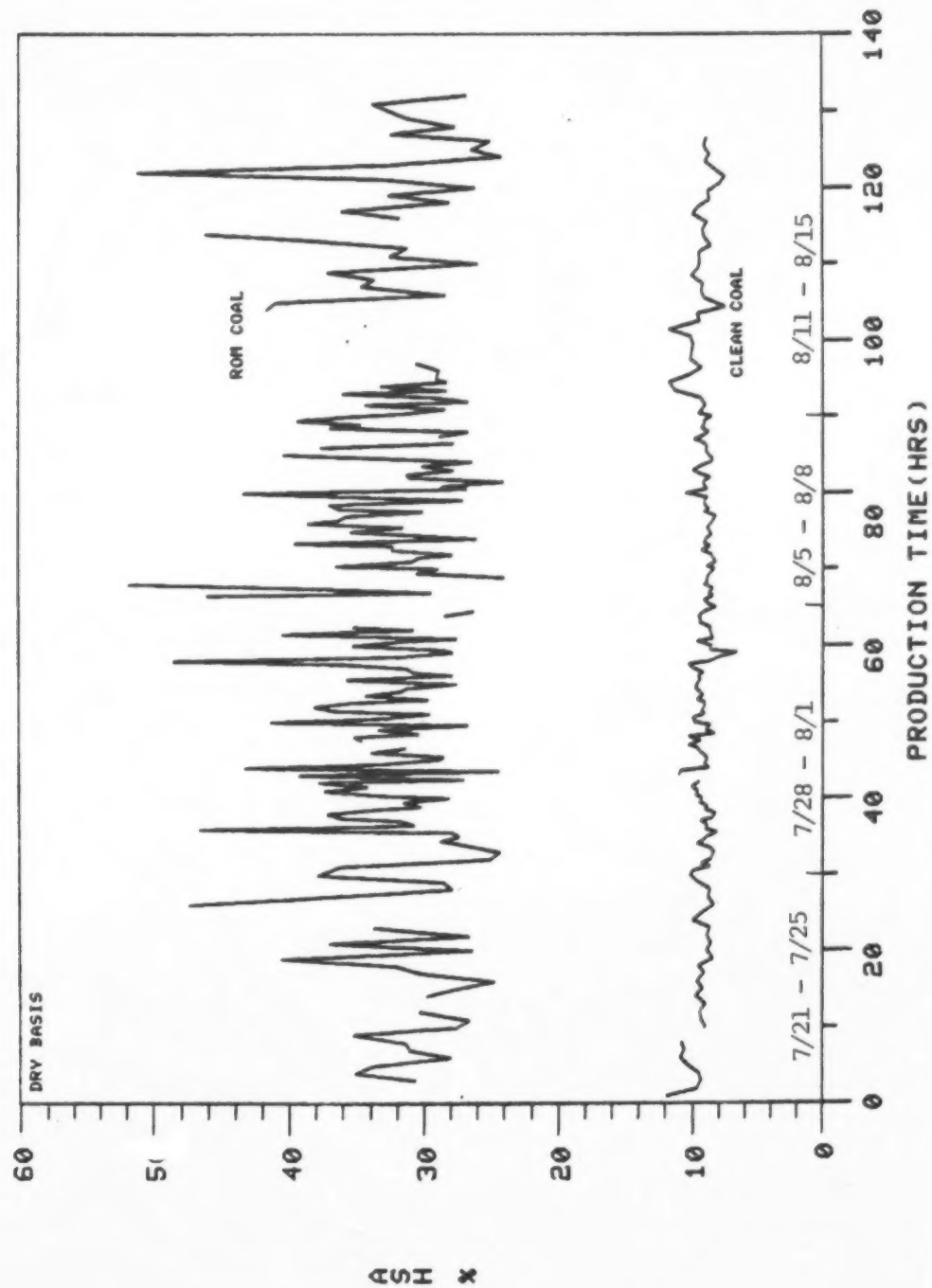


Figure 5-27. Republic Steel Corporation - hourly increment data for ash content.

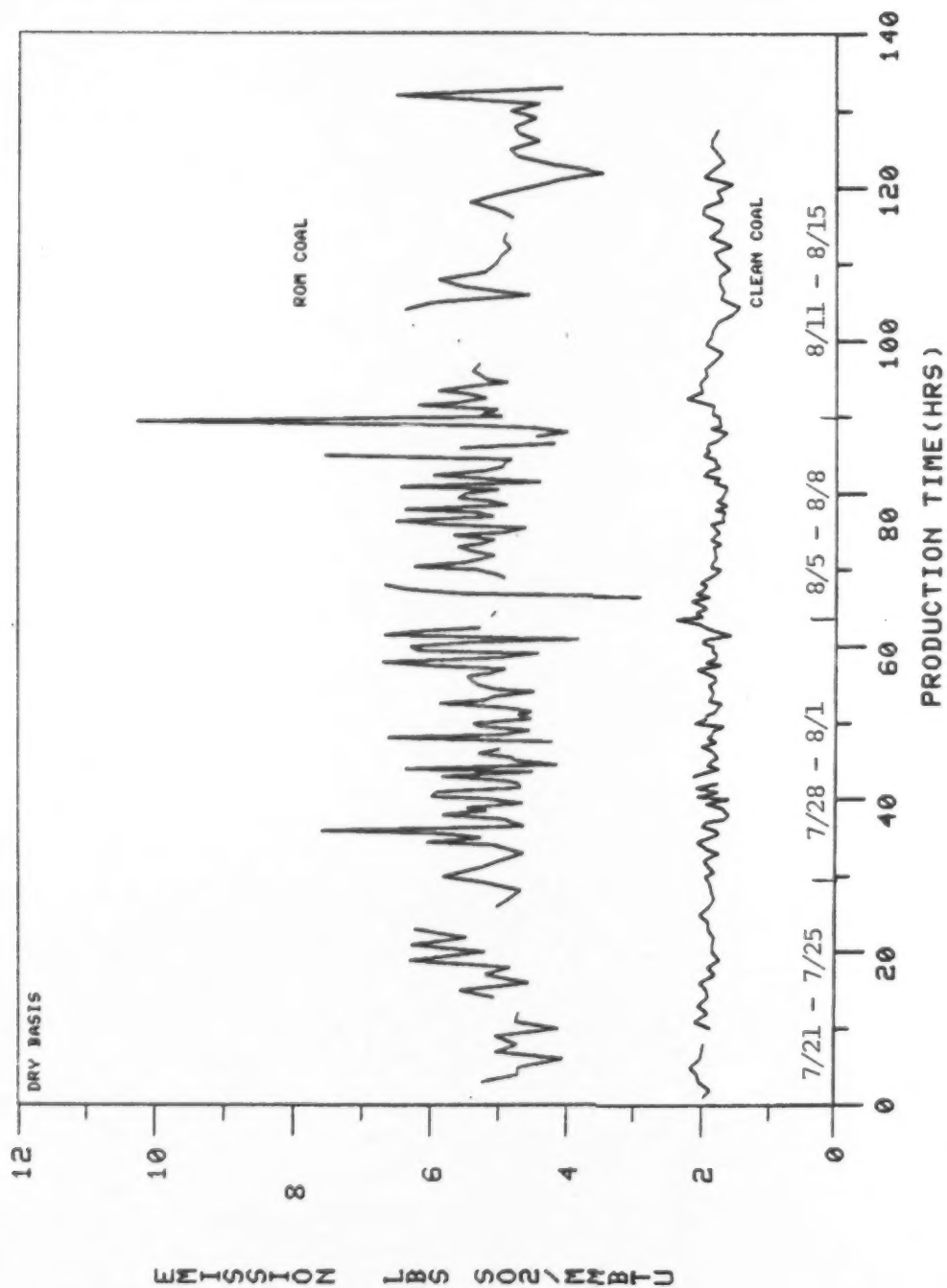


Figure 5-28. Republic Steel Corporation - hourly increment data for sulfur dioxide emission rate.

TABLE 5-5. REPUBLIC STEEL CORPORATION - HOURLY DATA (4 WEEKS)
ROM COAL STATISTICAL SUMMARY

	MEAN*	VARIANCE†		STANDARD DEVIATION*		RSD		ANALYSIS VARIANCE†		STANDARD DEVIATION*		ANALYSIS RSD	
		$\bar{x}$	S^2	S	$S/\bar{x}$	S^2	$S_a/\bar{x}$	S^2	S_a	$S_a/\bar{x}$	$S_a/\bar{x}$	$S_a/\bar{x}$	$S_a/\bar{x}$
Total Sulfur	2.576	2.576	0.101	0.317	0.123	0.005	0.068	0.005	0.068	0.027	0.027	0.027	0.027
Pyritic Sulfur	1.560	1.560	0.048	0.219	0.140	0.005	0.070	0.005	0.070	0.045	0.045	0.045	0.045
Organic Sulfur	1.016	1.016	0.038	0.196	0.193	NA	NA	NA	NA	NA	NA	NA	NA
Heating Value	10,098	10,098	774,382	879.99	0.087	3,024	54.99	3,024	54.99	0.005	0.005	0.005	0.005
Ash Content	32.285	32.285	29,540	5.435	0.168	0.065	0.255	0.065	0.255	0.008	0.008	0.008	0.008
Total Moisture	4.766	4.766	1.062	1.031	0.216	0.000	0.017	0.000	0.017	0.003	0.003	0.003	0.003
Emission Rate	5.117	5.117	0.419	0.647	0.126	NA	NA	NA	NA	NA	NA	NA	NA

CLEAN COAL STATISTICAL SUMMARY												
Total Sulfur	1.309	1.309	0.007	0.085	0.065	0.002	0.049	0.002	0.049	0.037	0.037	0.037
Pyritic Sulfur	0.558	0.558	0.005	0.073	0.130	0.001	0.032	0.001	0.032	0.058	0.058	0.058
Organic Sulfur	0.752	0.752	0.005	0.072	0.096	NA	NA	NA	NA	NA	NA	NA
Heating Value	13,957	13,957	29,672	172.26	0.012	4,612	67.91	4,612	67.91	0.005	0.005	0.005
Ash Content	9.367	9.367	0.068	0.780	0.063	0.031	0.175	0.031	0.175	0.019	0.019	0.019
Total Moisture	7.180	7.180	4.672	2.161	0.301	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Emission Rate	1.875	1.875	0.017	0.131	0.070	NA	NA	NA	NA	NA	NA	NA

* Units are weight % for sulfur, ash and moisture, Btu/lb for heating value, and lb SO₂/10⁶ Btu for emission rate.
† Units are weight %² for sulfur, ash and moisture, (Btu/lb)² for heating value, and (lb SO₂/10⁶ Btu)² for emission rate.
NA: S_a not applicable because organic sulfur and emission rate were not directly measured.

TABLE 5-6. REPUBLIC STEEL CORPORATION - HALF-HOUR DATA (2 WEEKS)

ROM COAL STATISTICAL SUMMARY

	MEAN*	VARIANCE†		STANDARD DEVIATION*		RSD		ANALYSIS VARIANCE†		ANALYSIS STANDARD DEVIATION*		ANALYSIS RSD	
		$\bar{x}$	S^2	S	$S/\bar{x}$	S^2	S_a	S_a^2	$S_a/\bar{x}$	S_a	$S_a/\bar{x}$	S_a	$S_a/\bar{x}$
Total Sulfur	2.643		0.113	0.336	0.128	0.004	0.065	0.004	0.025	0.065	0.025	0.025	0.025
Pyritic Sulfur	1.588		0.060	0.244	0.154	0.006	0.077	0.006	0.048	0.077	0.048	0.048	0.048
Organic Sulfur	1.018		0.045	0.213	0.209	NA	NA	NA	NA	NA	NA	NA	NA
Heating Value	9,946		762,976	873.49	0.092	3,395	58.27	3,395	0.006	58.27	0.006	0.006	0.006
Ash Content	32.913		27.050	5.201	0.167	0.070	0.265	0.070	0.008	0.265	0.008	0.008	0.008
Total Moisture	4.716		0.929	0.964	0.204	0.000	0.014	0.000	0.003	0.014	0.003	0.003	0.003
Emission Rate	5.350		0.735	0.857	0.151	NA	NA	NA	NA	NA	NA	NA	NA

CLEAN COAL STATISTICAL SUMMARY

Total Sulfur	1.304		0.007	0.085	0.065	0.002	0.045	0.002	0.034	0.045	0.034	0.034	0.034
Pyritic Sulfur	0.545		0.005	0.073	0.133	0.001	0.035	0.001	0.065	0.035	0.065	0.065	0.065
Organic Sulfur	0.758		0.006	0.076	0.100	NA	NA	NA	NA	NA	NA	NA	NA
Heating Value	13,957		38,353	195.84	0.014	3,797	61.62	3,797	0.004	61.62	0.004	0.004	0.004
Ash Content	9.180		0.327	0.572	0.062	0.027	0.163	0.027	0.018	0.163	0.018	0.018	0.018
Total Moisture	7.380		5.081	2.254	0.305	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Emission Rate	1.867		0.017	0.131	0.070	NA	NA	NA	NA	NA	NA	NA	NA

* Units are weight % for sulfur, ash and moisture, Btu/lb for heating value, and lb SO₂/10⁶ Btu for emission rate.† Units are weight %² for sulfur, ash and moisture, (Btu/lb)² for heating value, and (lb SO₂/10⁶ Btu)² for emission rate.NA: S_a not applicable because organic sulfur and emission rate were not directly measured.

In addition, the variances for total sulfur, pyritic sulfur, heating value, ash content, and emission rate have been dramatically reduced as the coal is processed and cleaned. The plant operating conditions that produce metallurgical grade coal substantially contribute to the sizable reduction in variance.

Daily, Weekly, and Monthly Composite Data

Figures 5-29 through 5-33 illustrate the daily composite data including the calculation of the emission rate for feed and clean coal samples collected at Republic Steel. Daily composites were prepared for raw and clean coal samples collected either hourly or every half-hour based upon the normal six to seven hour production day.

The results do indicate that the sample variance is reduced with larger lot sizes of coal. The daily raw coal composite samples represent approximately 5,000 tons, and the clean coal composite samples represent 3,000 tons. With these lot sizes, variations are evident from day to day but have been significantly dampened.

SUMMARIZED DATA FROM R & F AND REPUBLIC STEEL

The R & F Coal Company and Republic Steel Corporation raw and clean coal data which were previously presented separately, have been compiled and are displayed in Table 5-7 by data set. Five data sets for R&F and four data sets for Republic are shown. Data Sets I and II are 30-minute increment samples taken over two non-overlapping time periods. These data sets are combined to form Data Set III. Data Sets IV and V included the time periods in III, but the sample increments for IV and V were eight hours and weekly, respectively. The first Republic data set (VI) was taken over a two week period encompassing the period of Data Set VI. Each Republic set represents different sample time increments.

EFFICIENCY OF SULFUR REMOVAL BY COAL CLEANING

Presentation of Efficiencies

It was the intent at the outset of this program to calculate sulfur and ash removal efficiencies and potential SO₂ emission level reduction in

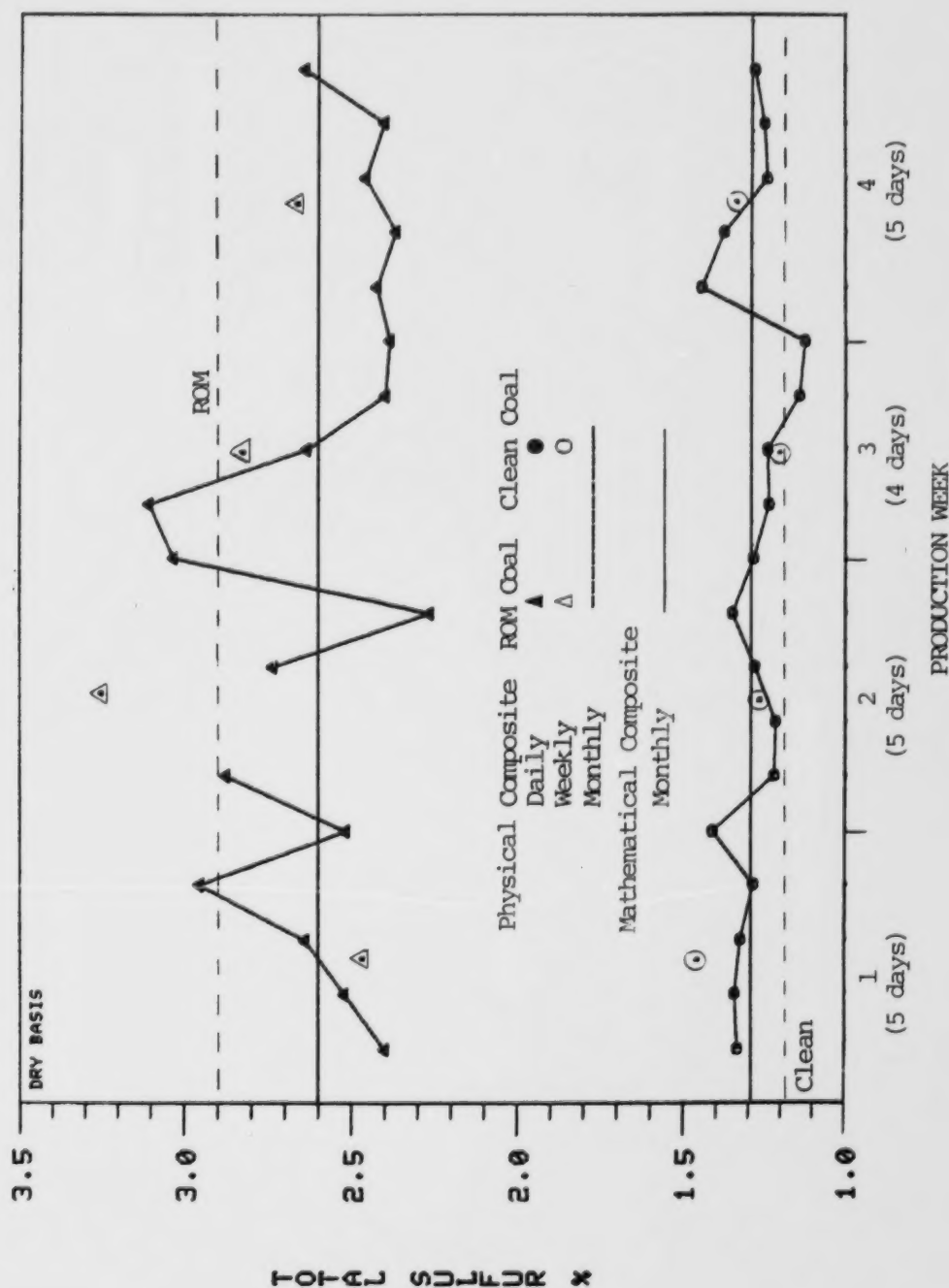


Figure 5-29. Republic Steel Corporation - daily, weekly, monthly composite data for total sulfur.

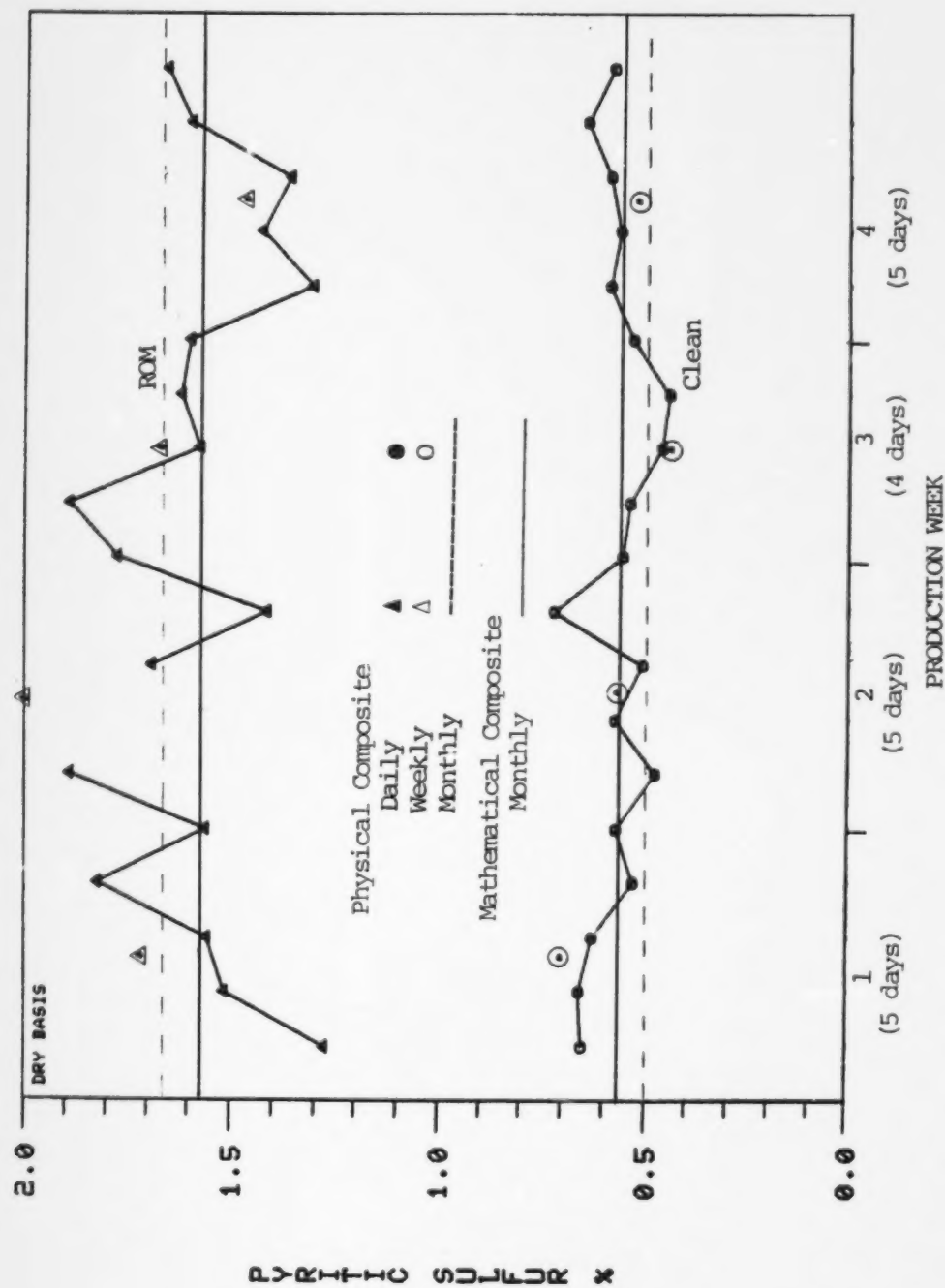


Figure 5-30. Republic Steel Corporation - daily, weekly, monthly composite data for pyritic sulfur.

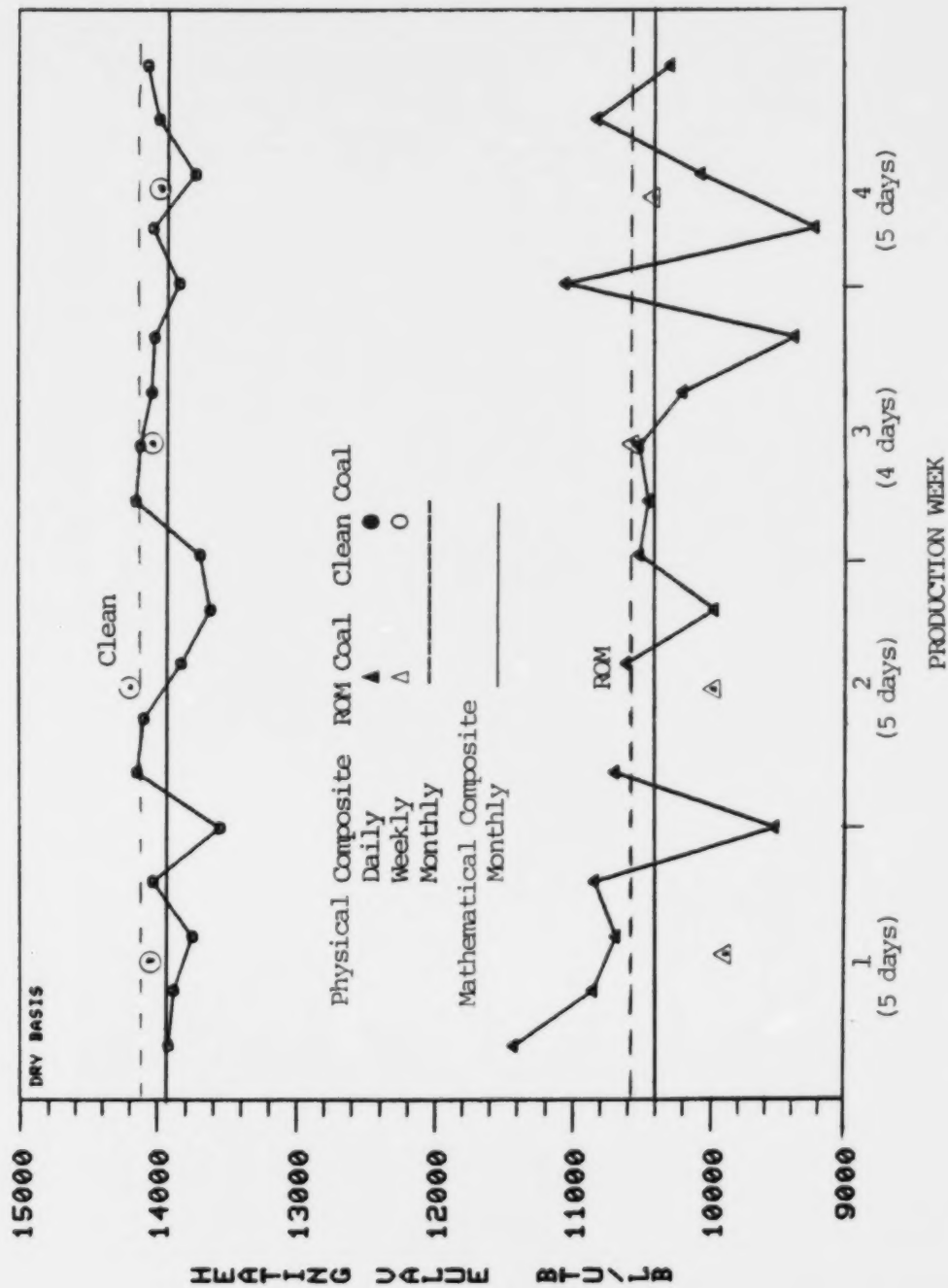


Figure 5-31. Republic Steel Corporation - daily, weekly, monthly composite data for heating value.

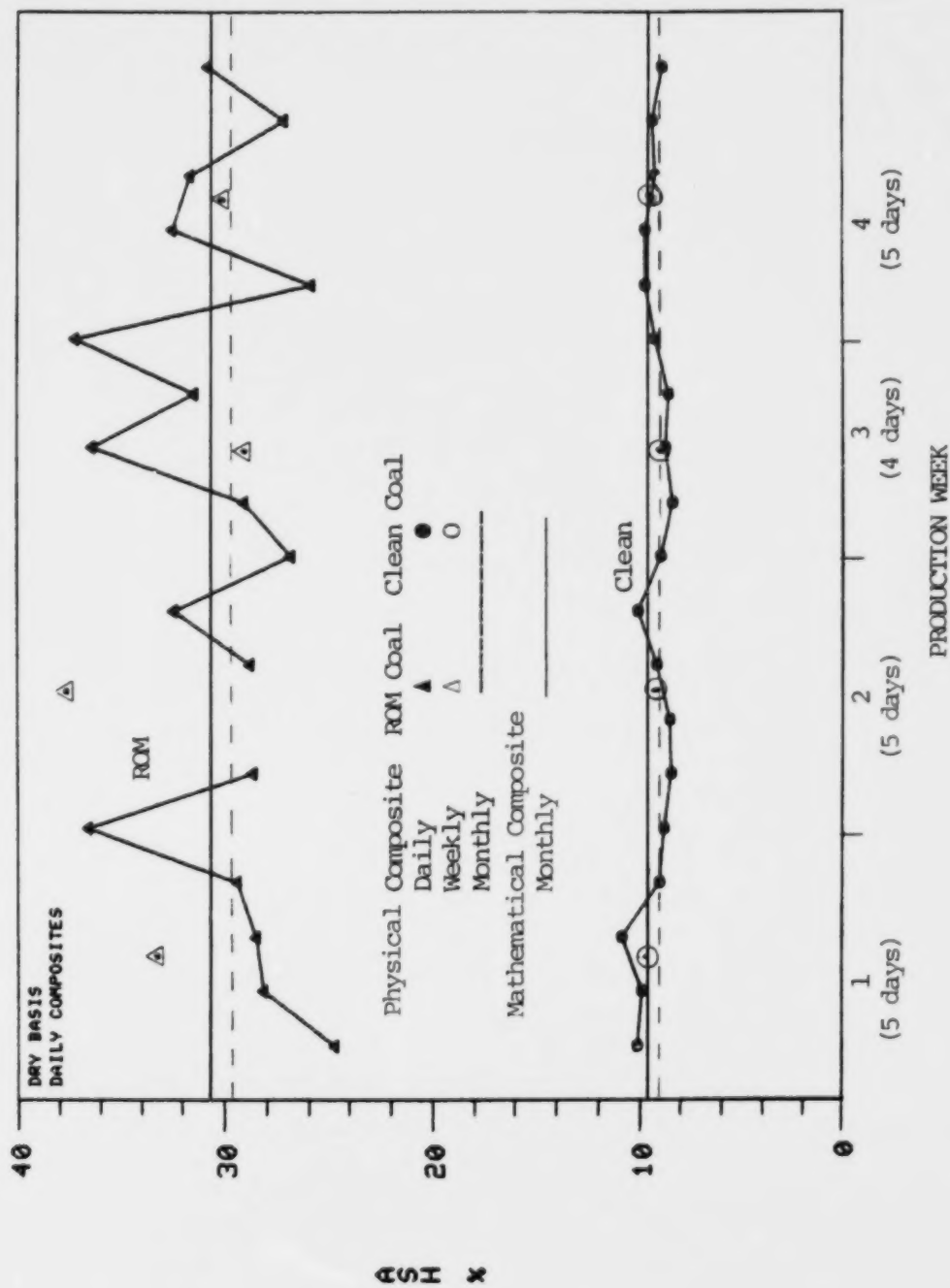


Figure 5-32. Republic Steel Corporation - daily, weekly, monthly composite data for ash content.

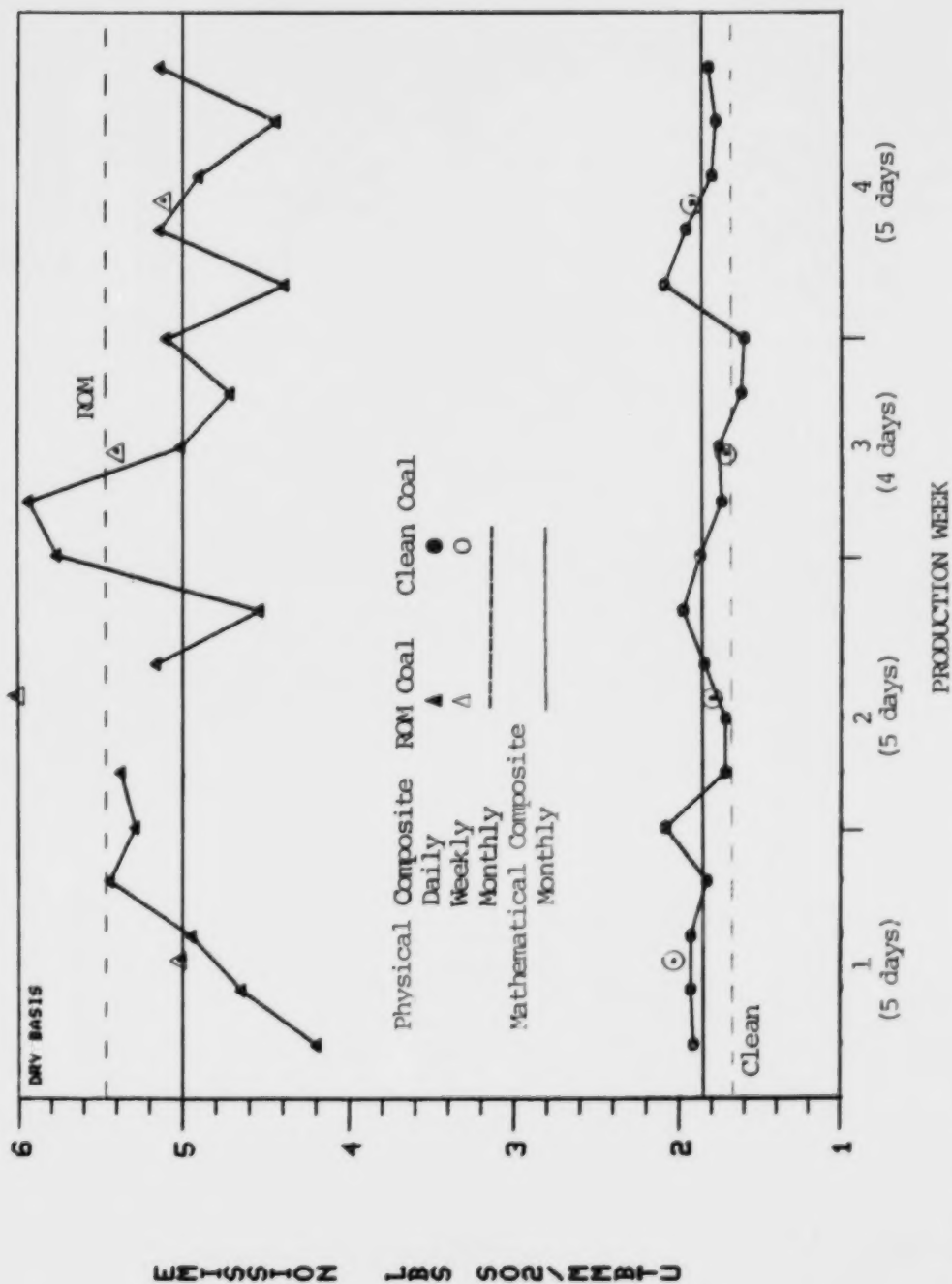


Figure 5-33. Republic Steel Corporation - daily, weekly, monthly composite data for sulfur dioxide emission rate.

TABLE 5-7. COMPARISON OF MEASURED DATA SETS

Parameter	Statistic	REP. I 4/29-4/30 30-Min. Incr.		REP. II 5/19-5/23 30-Min. Incr.		REP. III 4/29-5/23 30-Min. Incr.		REP. IV 4/22-6/5 8-Hr. Intvl.		REP. V 4/22-6/5 Weekly Intvl.		REP. VI Weeks 2,3 30-Min. Incr.		REP. VII Weeks 1,2,3,4 1-Hr. Incr.		REP. VIII Weeks 1,2,3,4 Daily Intvl.		REP. IX Weeks 1,2,3,4 Wkly. Intvl.	
		Raw	Clean	Raw	Clean	Raw	Clean	Raw	Clean	Raw	Clean	Raw	Clean	Raw	Clean	Raw	Clean	Raw	Clean
No. Samples	N	44	41	74	78	118	119	32	33	4	4	113	120	123	126	18	19	4	4
Total Sulfur, Percent (Dry Basis)	$\bar{x}$ S^2 S RSD	2.822 0.045 0.212 0.075	2.390 0.011 0.106 0.044	3.227 0.196 0.442 0.137	2.729 0.079 0.281 0.103	3.076 0.194 0.441 0.143	2.612 0.082 0.286 0.109	3.217 0.085 0.291 0.091	2.667 0.042 0.206 0.077	3.280 0.0072 0.085 0.026	2.695 0.0048 0.070 0.026	2.643 0.115 0.339 0.128	1.304 0.0072 0.085 0.065	2.576 0.101 0.317 0.123	1.309 0.0072 0.085 0.065	2.600 0.062 0.249 0.096	1.287 0.0069 0.083 0.065	2.800 0.114 0.338 0.121	1.308 0.015 0.121 0.092
Pyritic Sulfur, Percent (Dry Basis)	$\bar{x}$ S^2 S RSD	1.578 0.063 0.252 0.160	1.239 0.015 0.124 0.100	1.999 0.176 0.420 0.210	1.339 0.060 0.245 0.183	1.842 0.175 0.418 0.227	1.305 0.047 0.216 0.166	1.860 0.106 0.325 0.175	1.318 0.031 0.177 0.135	1.823 0.025 0.157 0.086	1.290 0.037 0.191 0.148	1.625 0.064 0.252 0.155	0.545 0.0053 0.073 0.133	1.560 0.048 0.219 0.140	0.558 0.0053 0.073 0.130	1.585 0.034 0.185 0.117	0.571 0.0050 0.071 0.125	1.748 0.081 0.104 0.163	0.550 0.011 0.104 0.190
Organic Sulfur, Percent (Dry Basis)	$\bar{x}$ S^2 S RSD	1.244 0.035 0.187 0.150	1.151 0.029 0.169 0.147	1.228 0.075 0.274 0.223	1.390 0.081 0.285 0.205	1.234 0.102 0.320 0.259	1.308 0.076 0.275 0.210	1.357 0.097 0.312 0.230	1.350 0.046 0.215 0.160	1.413 0.066 0.258 0.182	1.405 0.015 0.122 0.087	1.018 0.045 0.213 0.209	0.758 0.0058 0.076 0.100	1.016 0.038 0.196 0.193	0.752 0.0052 0.072 0.096	1.015 0.020 0.141 0.139	0.716 0.0058 0.076 0.106	1.053 0.048 0.219 0.208	0.758 0.026 0.051 0.067
Heating Value Btu/lb (Dry Basis)	$\bar{x}$ S^2 S RSD	11,117 23,167 152.2 0.014	12,156 47,293 217.5 0.018	11,296 188,185 433.8 0.038	12,395 118,957 344.9 0.028	11,229 137,020 370.2 0.033	12,313 101,387 318.4 0.026	11,189 91,405 302.3 0.027	12,523 98,531 313.9 0.025	11,292 39,182 197.9 0.018	12,593 16,261 127.5 0.010	9,946 762,976 873.5 0.088	13,957 38,353 195.8 0.014	10,098 774,382 880.0 0.087	13,957 29,672 172.3 0.012	10,397 341,685 584.5 0.056	13,911 34,162 184.8 0.013	10,236 119,342 345.5 0.034	14,002 4,313 65.7 0.0047
Ash Content, Percent (Dry Basis)	$\bar{x}$ S^2 S RSD	20,592 4,827 2,197 0.107	14,076 0.850 0.922 0.066	20,146 8,235 2,870 0.142	12,190 5,464 2,338 0.192	20,312 6,958 2,638 0.130	12,840 4,663 2,159 0.168	22,497 1,914 1,384 0.061	13,370 1,227 1,108 0.083	21,820 1,383 1,176 0.054	13,205 0.162 0.403 0.030	32,913 27,050 5,201 0.158	9,180 0.327 0.572 0.062	32,285 29,540 5,435 0.168	9,367 0,608 0,780 0,083	30,321 13,107 3,620 0,119	9,302 0,431 0,656 0,071	32,495 15,542 3,942 0,121	9,253 0,163 0,403 0,044
Total Moisture, Percent (As Received)	$\bar{x}$ S^2 S RSD	6,994 0.923 0.961 0.137	7,917 6,648 2,578 0.326	7,316 1,276 1,130 0.154	6,714 2,832 1,683 0.251	7,196 1,159 1,077 0.150	7,129 4,430 2,105 0.295	5,297 1,376 1,173 0.186	6,202 2,306 1,519 0.245	5,845 0,457 0,676 0,116	5,640 0,016 0,127 0,022	4,513 0,496 0,704 0,156	7,380 5,081 2,254 0,305	4,766 1,062 1,031 0,216	7,180 4,672 2,161 0,301	5,139 1,547 1,244 0,242	7,559 3,272 1,809 0,239	4,610 0,049 0,222 0,048	7,070 0,123 0,351 0,050
lbs SO ₂ per 10 ⁶ Btu	$\bar{x}$ S^2 S RSD	5,073 0.163 0.403 0.080	3,928 0.029 0.169 0.043	5,716 0.643 0.802 0.140	4,399 0.195 0.441 0.100	5,476 0.559 0.748 0.137	4,237 0.188 0.433 0.102	5,747 0.277 0.526 0.092	4,257 0.110 0.331 0.078	5,728 0.118 0.343 0.060	4,275 0,016 0,127 0,030	5,350 0,735 0,857 0,160	1,867 0,0172 0,131 0,070	5,117 0,419 0,647 0,126	1,875 0,0172 0,131 0,070	5,004 0,218 0,467 0,093	1,850 0,018 0,135 0,073	5,470 0,478 0,691 0,126	1,866 0,031 0,175 0,094

30 or 60 minute increments. This was to be done using a sample-by-sample comparison of ROM and clean coal samples collected either at the same time or with a time lag between the samples that would be determined by the individual operating characteristics of the two plants. Two factors, however, render such a comparison impossible. At the Republic Steel Corporation facility, the coal feed rate fluctuated significantly during an hourly period. The once-an-hour observations of feed and production rates did not reflect a process at steady state. Therefore, there were periods when coal was being fed into the plant but when no product was being produced or periods when there was no feed but when clean coal could be collected.

Secondly, one of the initial steps in the coal preparation process was splitting the ROM coal into course, medium, and fine coal streams. Each stream was processed at a different rate and fed to a conveyor up stream from the clean coal sampling station. These two facts effectively obscure any consistent time relationship between ROM and clean coal samples and make any meaningful calculations of instantaneous efficiencies based on the data in-hand impossible. Therefore, the removal efficiencies were calculated based on daily feed and production figures as well as on the analysis of daily composite samples. The formula that was used to calculate the removal efficiency for any parameter, P, is:

$$\eta = 1 - (\text{yield}) \frac{P_{\text{clean}}}{P_{\text{ROM}}}$$

where η is the cleaning efficiency, yield is the fraction of ROM coal that reports to the clean coal stream, and P is the weight concentration, for sulfur, ash, or the SO_2 emission parameter. The yield at the R & F plant was calculated from the total tonnages processed and produced during the sampling period to be 0.77 and was assumed to have remained constant during the period of interest. The yield at the Republic plant was calculated on a daily basis from hourly readings that were taken from the ROM and clean coal belt scales. Calculated ash and total sulfur removal efficiencies and reduction in potential SO_2 , along with relevant statistical parameters, are shown in Table 5.8 for the R & F data and Table 5.9 for the Republic data.

TABLE 5-8. R&F COAL COMPANY-COAL CLEANING EFFICIENCIES

SAMPLING DAY	REDUCTION EFFICIENCIES *		
	η_A	η_{TS}	η_E
1	0.56	0.36	0.44
2	0.57	0.45	0.52
3	0.55	0.35	0.42
4	0.53	0.33	0.40
6	0.55	0.31	0.39
13	0.49	0.34	0.41
14	0.57	0.41	0.48
17	0.54	0.36	0.43
18	0.60	0.43	0.50
MEAN	0.55	0.37	0.44
STANDARD DEVIATION	0.0290	0.0465	0.0445
VARIANCE	0.0008	0.0022	0.0020
RSD	0.0528	0.1254	0.100
NO. OF POINTS	9	9	9

* Subscripts:

A = ash

TS = total sulfur

E = SO₂ emission parameter (lb SO₂/10⁶Btu)

TABLE 5-9. REPUBLIC STEEL CORPORATION-COAL CLEANING EFFICIENCIES

SAMPLING DAY	REDUCTION EFFICIENCIES *		
	η_A	η_{TS}	η_E
22	0.78	0.67	0.74
23	0.79	0.72	0.78
24	0.81	0.73	0.79
25	0.86	0.67	0.77
28	0.86	0.80	0.85
29	0.85	0.74	0.50
30	0.80	0.74	0.80
31	0.86	0.81	0.86
32	0.86	0.73	0.80
33	0.55	0.73	0.81
34	0.87	0.76	0.84
35	0.68	0.50	0.60
36	0.84	0.69	0.80
37	0.84	0.73	0.80
38	0.79	0.69	0.76
39	0.83	0.71	0.79
MEAN	0.82	0.71	0.79
STANDARD DEVIATION	0.0466	0.0683	0.0573
VARIANCE	0.0022	0.0047	0.0033
RSD	0.0568	0.0963	0.0728
NO. OF POINTS	16	16	16

* Subscripts

A = ash

TS = total sulfur

E = SO₂ emission parameter (lb SO₂/10⁶Btu)

SECTION 6.0

UNCERTAINTY IN MEASURED DATA

Prior to analyzing the variability in the coal data, an evaluation was made of the uncertainty in the data. The uncertainty in the variance of the data consists of four fundamental components: the variance for laboratory analysis of prepared subsamples (V_{analysis}), the variance for preparation of laboratory subsamples ($V_{\text{sample preparation}}$), the variance for physically compositing multiple primary coal-stream samples which were taken over an interval of time ($V_{\text{compositing}}$) and the variance for primary sampling of the coal stream (V_{sampling}). The aggregate uncertainty provides a quantitative limitation to subsequent explanations of coal variability.

VARIANCES FOR PRIMARY SAMPLING

V_{sampling} is the component of variability in coal data attributable to any imperfections in acquiring primary samples from the plant's coal streams. For example, samples obtained as aliquots from a coal pile do not fully represent what the plant will use at any moment in time because the heterogeneous coal varies from point to point in the pile. Samplers used at both the R&F and Republic preparation plants, however, took full width cuts of the coal from the feed and product conveyor belts. These samples, then, were full cross-sections of the coal stream at the sampling point prior to, or immediately subsequent to, preparation, and the uncertainty introduced by V_{sampling} could be considered negligible.

VARIANCES FOR SAMPLE PREPARATION AND LABORATORY ANALYSIS

Prior to actual site testing, Versar established criteria for determining the reliability of chemical analyses conducted in the mobile laboratory using the procedures and instruments described in Section 4.0.

Since the same chemist would not perform all the analyses of samples for any one parameter, it became important to define the repeatability and reproducibility of each procedure using several chemists and technicians. Much of the sample preparation was also performed in the mobile laboratory. Prior to site testing, ASTM Standard D-2013 (Appendix A1) was used to check the precision of sample preparation at various stages.

Criteria for Evaluating Versar Laboratory Analyses

ASTM does not publish accepted statistical variances for analyses of total sulfur, ash, heating content, moisture, or pyritic sulfur at different concentrations or a relative standard deviation applicable to any concentration. ASTM has established precision limits for repeatability and reproducibility based upon the analyses of duplicate samples. Repeatability is defined by ASTM as the comparison of "the results of consecutive determinations carried out on the same sample in the same laboratory by the same operator using the same apparatus."⁽⁴⁾ Reproducibility is a comparison of the mean value of "duplicate determinations carried out by different laboratories on representative samples taken from the same bulk sample after the last stage of reduction."⁽⁴⁾ These precision limits are commonly provided for several broad concentration ranges (i.e., coals containing less than two percent sulfur and coals with more than two percent sulfur). A criterion was established to allow Versar's analyses to be compared from day-to-day, from site-to-site, and with previous data to ensure that results of duplicate analyses conformed to ASTM precision limits. Standard deviation and relative standard deviation criteria were established for each parameter based on the ASTM reproducibility precision limit and reported concentrations of the coal samples being analyzed. The reproducibility value was used since mobile laboratory conditions could vary from site-to-site and because more than one analyst would be performing the same test.

The standard deviation and relative deviation limits were calculated as follows:

Less than 2% sulfur, the limit is = 0.15%

Greater than 2% sulfur, the limit is = 0.25%

For example, for 1.50% mean sulfur coal, the range of acceptable values for duplicate analyses is 1.425% to 1.575% (i.e., a maximum difference of 0.15%). Based on this difference, a maximum allowable variance can be established where

$$s^2 = \frac{\sum (x_i - \bar{x})^2}{N} = \frac{.15^2}{2} = 0.011$$

$$s = 0.106$$

and a relative standard deviation (RSD) can be computed for 1.50% sulfur coal which will serve as the accept-reject criteria for Versar sulfur analyses.

$$RSD_{1.50} = \frac{s}{\bar{x}} = \frac{0.106}{1.50} = 0.071$$

The RSD for a high sulfur coal at 3.59% sulfur can also be computed using the ASTM reproducibility precision limit of 0.25%.

$$s^2 = \frac{0.25^2}{2} = 0.031$$

$$s = 0.177$$

$$RSD_{3.59} = \frac{0.177}{3.59} = 0.049$$

Table 6-1 lists the mean, standard deviation and RSD values for each parameter analyzed during experimental calibration phase based on ASTM precision limits published for each parameter.

TABLE 6-1
CRITERIA FOR EVALUATING LABORATORY ANALYSES
REPRODUCIBILITY AND VARIANCE

<u>Parameter</u>	<u>Mean Value</u>	<u>ASTM Reproducibility⁽²⁾ Precision Limit</u>	<u>Variance</u>	<u>RSD</u>
Total sulfur	1.50% 3.59%	0.15% 0.25%	0.011 0.031	0.071 0.049
Ash	12.0%	1.0%	0.500	0.059
Heating Value	12,000 Btu/lb	100 Btu/lb	5,040	0.006
Moisture	0.48%	0.50%	0.125	0.735
Pyritic sulfur	1.20%	0.30%	0.045	0.177

Criteria for Evaluating Versar Sample Preparation and Laboratory Analysis Variation

Keller⁽³⁾ and Aresco and Orning⁽⁴⁾ experimentally determined, for coal sulfur and ash concentrations, the variability components of sample preparation and laboratory analysis. In their tests, field sample preparation, laboratory sample preparation, and laboratory analysis variations were determined using ASTM Standard D-2013. Their results are listed in Table 6-2.

TABLE 6-2

HISTORICAL VARIANCES FOR SAMPLE PREPARATION AND ANALYSIS^(3, 4)

			Sample Preparation	Laboratory Analysis	Preparation and Analysis
Ash Content, Percent	Raw Coals (N=206)	S ²	0.0453	0.0138	0.0611
		RSD	0.0149	0.0080	0.0169
	Washed Coals (N=156)	S ²	0.0061	0.0040	0.0101
		RSD	0.0126	0.0114	0.0170
Total Sulfur Percent	Raw Coals (N=90)	S ²	NS*	NS*	0.0014
		RSD			0.019
	Washed Coals (N=70)	S ²	NS*	NS*	0.001
		RSD			0.006

*Not separately determined.

To establish the variation associated with the successive steps in the coal measurement process, Versar performed precision and standardization evaluations of our specific sub-sampling, sample reduction, and analysis procedures in accordance with ASTM Standard D-2013. Versar obtained four 300 pound coal lot increments from two different sources (Helen and Helvetia mines at Homer City, Pennsylvania). Each of these eight sample increments (Source 1, Increments 1-4 and Source 2, Increments 1-4) were prepared and analyzed for total sulfur, ash, heating value, moisture, and pyritic sulfur as illustrated in Figure 6-1. Results of these tests, given in Table 6-3, defined the sample preparation and sample analyses variations associated with Versar's mobile laboratory operations. Comparisons of these RSD values to Keller's raw coal data pooled RSDs show both data sets have similar variations (Table 6-2). All data generated by Versar from ASTM Standard D-2013 testing of Homer City coal samples indicated that the

TABLE 6-3. VERSAR DETERMINATION OF SAMPLE PREPARATION AND LABORATORY ANALYSIS VARIANCES (HOMER CITY COAL SAMPLES)

Parameter	Sample Preparation		Laboratory Analysis	
	Variance	RSD	Variance	RSD
Total Sulfur (%)	0.0032	0.023	0.0008	0.019
Ash (%)	0.180	0.019	0.056	0.0110
Heating Value (Btu/lb)	9,788	0.008	1,314	0.003
Moisture (%)	0.0209	0.36	0.0050	0.18
Pyritic Sulfur (%)	0.0077	0.038	0.0042	0.028

standard deviations and relative standard deviations for laboratory analysis of all parameters were lower than the ASTM values calculated in Table 6-1. The variations were also considered to be small compared to the much larger lot size components of sulfur variability.

Versar performed similar evaluations of laboratory analytical precision during the actual testing of R&F Coal Company and Republic Steel. Averages of daily checks according to ASTM Standard D-2013 provided the results shown in Table 6-4.

TABLE 6-4
VERSAR MEASURED
LABORATORY ANALYSIS VARIANCES

Parameter	R&F Coal				Republic Steel			
	Raw Coal		Clean Coal		Raw Coal		Clean Coal	
	S	RSD	S	RSD	S	RSD	S	RSD
Total Sulfur (%)	0.065	0.023	0.062	0.026	0.085	0.052	0.068	0.040
Ash (%)	0.18	0.009	0.15	0.011	0.29	0.009	0.16	0.018
Heat Value (Btu/lb)	75	0.006	77	0.006	82	0.008	76	0.005
Moisture (%)	0.098	0.014	0.112	0.014	-	-	-	-
Pyritic Sulfur (%)	0.110	0.070	0.069	0.056	0.076	0.047	0.035	0.065

In addition to the daily inter-laboratory checks of precision, Versar also compared results of analyses conducted during the intensive studies (30-minute interval samples) with the same analysis conducted by R&F's laboratory on split portions of the same samples. Results of analyses performed by both laboratories are illustrated in Figure 6-2 through Figure 6-4. These figures should not be interpreted as a comparison of the

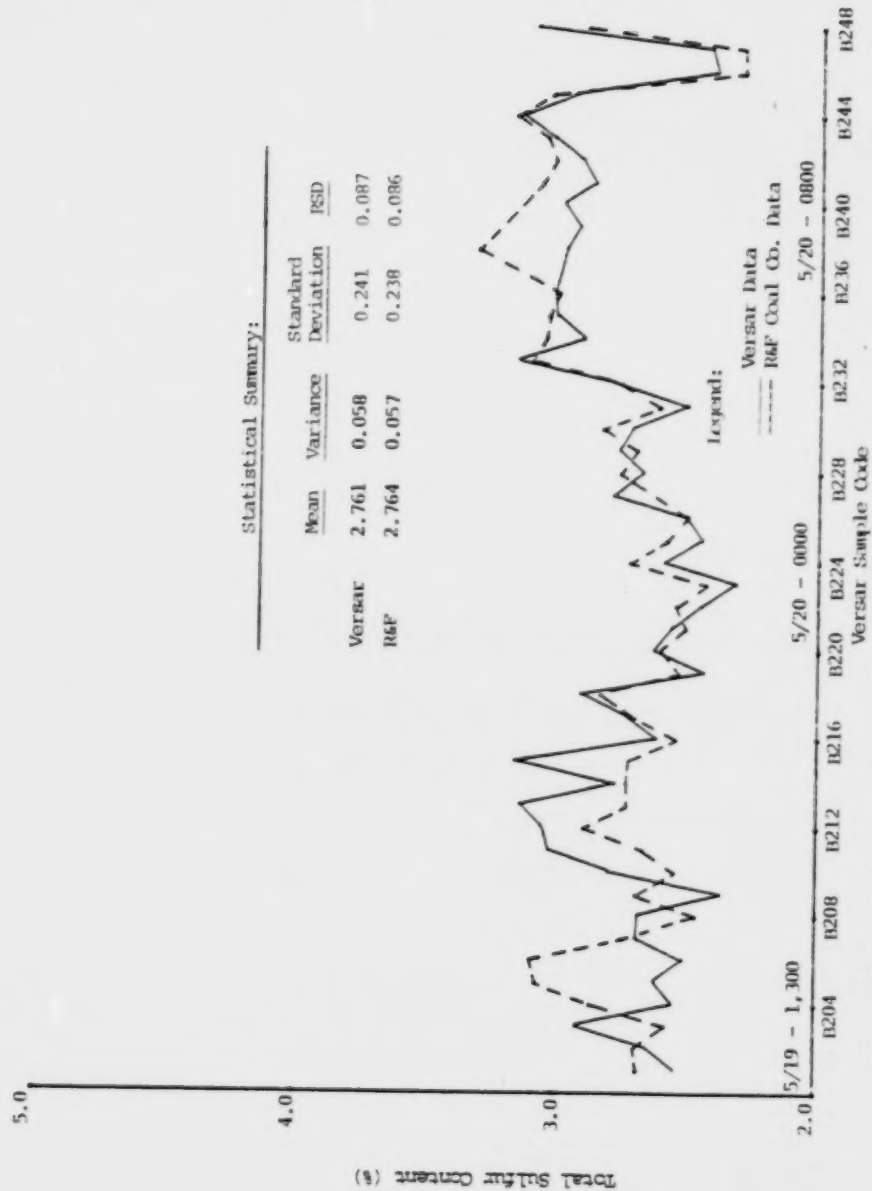


Figure 6-2. Total sulfur concentrations in clean coal by Versar Laboratory and R&F Coal Company Laboratory.

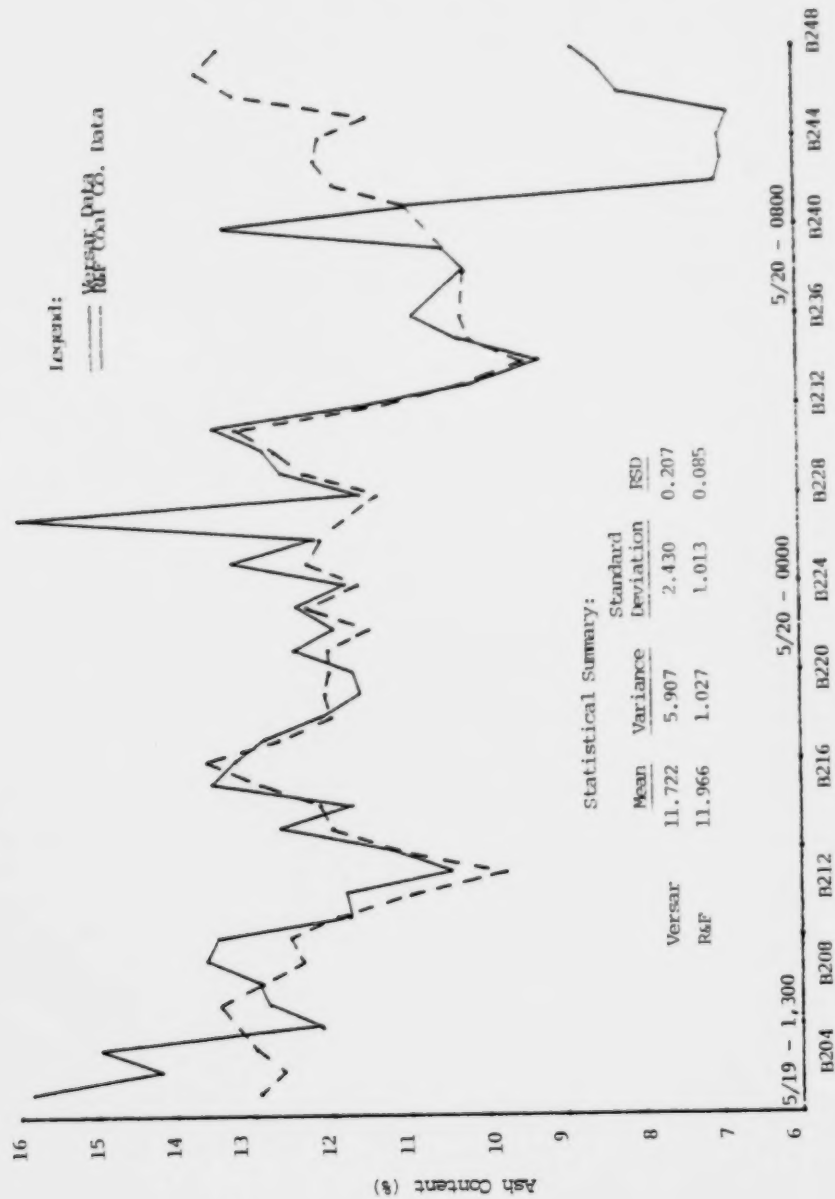


Figure 6-3. Ash content concentrations in clean coal by Versar's laboratory and R&F Coal Co. laboratory.

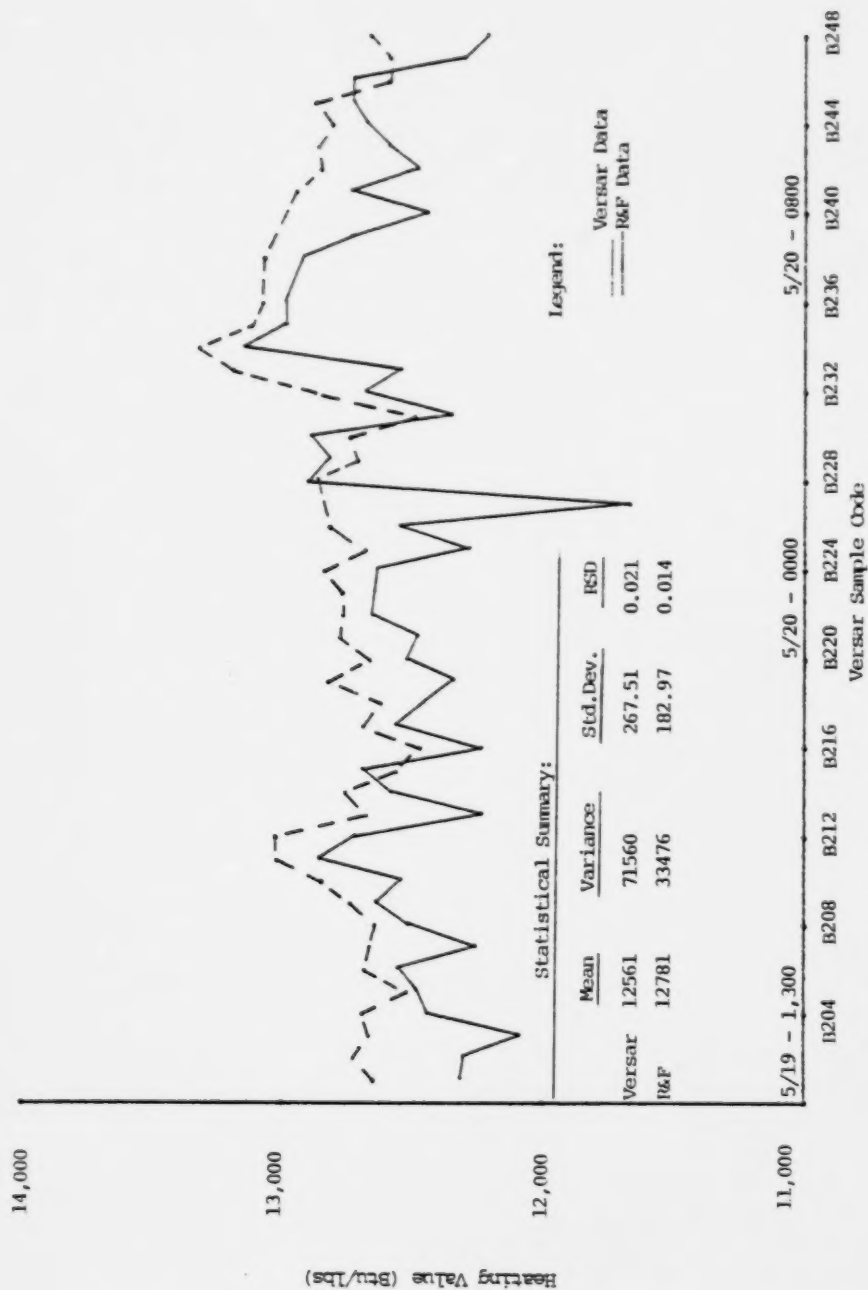


Figure 6-4. Heating values in clean coal by Versar's laboratory and R&F Coal Company laboratory.

accuracy of one laboratory versus the other. The analytical instruments and procedures which laboratories used both complied with ASTM specifications but were slightly different. The number of samples analyzed by R&F Coal Company does not match the number of samples processed by Versar, therefore a point by point comparison would not be valid. An inspection of the trend does give a good indication of the reproducibility between the laboratories. The total sulfur concentrations do match very closely, but there seem to be some minor discrepancies in the ash and heating value data. This error appears to be systematic and presumably related to the operator or to the calibration standard. The number and magnitude of these discrepancies do not significantly alter the data.

VARIANCE FOR COMPOSITING OF SAMPLES

At each of the preparation plants, daily and weekly physical composites were prepared from splits of the primary samples collected at 30-minute or 60-minute intervals. Sized subsamples of the primary samples and the physical composites were independently prepared and analyzed. At the R&F plant, flowrate data were not available, so the mathematical composite results are time-averaged. Conversely, the mathematical composite results for the Republic plant are flow-proportioned.

Tables 6-5 through 6-8 compare physical composites to mathematical composites for (respectively) R&F raw coal, R&F clean coal, Republic raw coal, and Republic clean coal. In each table, the differences P-M are listed, where P is the analytical result for physical composite and M is the corresponding value calculated as the mean of N incremental samples. The variances, calculated as $S^2 = \frac{\sum (P-M)^2}{2\sum N}$, the standard deviation and the relative standard deviation (RSD) are listed in Table 6-9. The RSDs were calculated using the mean values for Data Set III (R&F) and for Data Set VII (Republic) in Table 5-7.

The variances in Table 6-9 are estimates for $V_{\text{compositing}}$. Included in these variances are the uncertainties introduced by not flow-proportioning the mathematical composites for the R&F preparation plant, where the flowrate data were not available.

TABLE 6-5
COMPARISON OF PHYSICAL AND MATHEMATICAL COMPOSITES
R&F PLANT, RAW COAL

Physical (P) Composites	Type Ident.	8-Hour Intervals								
		531	532	533	631	1331	1332	1333	1431	1432
Mathematical Composites (M)	Type Ident. N	30-Minute Increments								
		A101- A115 15	A116- A119 4	A120- A132 13	A133- A144 12	B101- B116 11	B117- B132 15	B133- B148 16	C101- C116 16	C117- C130 14
Total Sulfur, Percent	P	2.93	2.96	2.79	3.22	3.47	3.11	3.48	3.43	3.46
	M	2.85	2.79	2.71	2.91	3.22	3.15	3.48	3.35	2.94
	P-M	0.08	0.17	0.08	0.31	0.25	-0.04	0.00	0.08	0.52
Pyritic Sulfur, Percent	P	1.77	1.68	1.50	1.73	2.00	1.65	1.97	2.10	2.14
	M	1.55	1.43	1.55	1.68	2.12	2.23	2.18	1.92	1.62
	P-M	0.22	0.25	-0.05	0.05	-0.12	-0.58	-0.21	0.18	0.52
Organic Sulfur, Percent	P	1.16	1.28	1.29	1.49	1.47	1.46	1.50	1.33	1.32
	M	1.30	1.36	1.16	1.23	1.10	0.92	1.30	1.43	1.32
	P-M	-0.14	-0.08	0.13	0.26	0.37	0.54	0.20	-0.10	0.00
Heating Value, Btu/lb	P	11,357	11,492	11,348	11,412	11,286	11,698	11,648	11,163	11,079
	M	11,114	11,319	11,162	11,005	11,144	11,501	11,586	11,169	11,015
	P-M	243	173	186	407	142	197	62	-6	64
Ash Content, Percent	P	20.86	20.46	20.89	21.20	22.31	19.56	19.82	21.92	23.21
	M	18.83	19.77	21.96	21.58	22.75	19.28	19.06	18.68	22.42
	P-M	2.03	0.69	-1.07	-0.38	-0.64	0.28	0.76	3.24	0.79
Total Moisture, Percent (As Rec'd)	P	6.52	7.56	7.07	6.84	8.10	7.26	6.95	3.92	5.23
	M	6.62	6.63	7.20	7.37	8.70	7.92	7.11	7.23	6.07
	P-M	-0.10	0.93	-0.13	-0.53	-0.60	-0.66	-0.16	-3.31	-0.84
lbs SO ₂ per 10 ⁶ Btu	P	5.15	5.14	4.92	5.64	6.14	5.31	5.96	6.14	6.24
	M	5.14	4.92	4.86	5.29	5.78	5.49	6.00	6.01	5.34
	P-M	0.01	0.22	0.06	0.35	0.36	-0.18	-0.04	0.13	0.90

P = Analytical Results,
M = Calculated Mean,
P-M = Difference between analytical results and calculated mean

(Continued)

TABLE 6-5 (Continued)
COMPARISON OF PHYSICAL AND MATHEMATICAL COMPOSITES
R&F PLANT, RAW COAL

Physical (P) Composites	Type Ident.	Weekly			
		1	2	5	7
Mathematical Composites (M)	Type Ident. N	Daily			
		131- 432 11	531- 632 5	1331- 1531 7	1631- 1931 8
Total	P	3.40	3.22	3.28	3.04
Sulfur,	M	3.25	3.15	3.28	3.22
Percent	P-M	0.15	0.07	0.00	-0.18
Pyritic	P	1.74	2.03	1.67	1.85
Sulfur,	M	1.64	1.77	2.01	2.09
Percent	P-M	0.10	0.26	-0.34	-0.24
Organic	P	1.66	1.19	1.61	1.19
Sulfur,	M	1.61	1.38	1.27	1.13
Percent	P-M	0.05	-0.19	0.34	0.06
Heating	P	11,040	11,228	11,453	11,447
Value,	M	11,039	11,390	11,193	11,160
Btu/lb	P-M	1	-162	260	287
Ash	P	22.98	20.26	21.64	22.40
Content,	M	22.82	20.93	22.23	23.30
Percent	P-M	0.16	-0.67	-0.59	-0.90
Total Moisture,	P	5.27	5.25	6.39	6.47
Percent	M	5.67	7.05	6.77	6.25
(As Rec'd)	P-M	-0.40	-1.80	-0.38	0.22
lbs SO ₂	P	6.15	5.73	5.72	5.31
per	M	5.87	5.53	5.85	5.77
10 ⁶ Btu	P-M	0.28	0.20	-0.13	-0.46

P = Analytical Results

M = Calculated Mean

P-M = Difference between analytical results and calculated mean

TABLE 6-6. COMPARISON OF PHYSICAL AND MATHEMATICAL COMPOSITES R&F PLANT, CLEAN COAL

Physical (P) Composites	Type Identifi- cation	8-Hour Intervals										Weekly			
		30-Minute Increments										8-Hour Intervals			
		541	641	1341	1342	1343	1441	1442	1	2	5	7			
Mathematical (M) Composites	Type Identifi- cation N	30-Minute Increments										8-Hour Intervals			
		A201- A215 14	A233- A244 11	B201- B216 16	B217- B232 16	B233- B248 15	C201- C216 15	C217- C230 14	141- 442 11	541- 642 3	1341- 1541 7	1641- 1941 10			
Total Sulfur, Percent	P	2.07	2.57	2.74	2.70	3.16	2.80	2.62	2.63	2.79	2.66	2.70			
	M	2.32	2.44	2.76	2.62	2.92	2.88	2.48	2.63	2.59	2.79	2.65			
	P-M	- 0.25	0.13	- 0.02	0.08	0.24	- 0.08	0.14	0.00	0.20	- 0.13	0.05			
Pyritic Sulfur, Percent	P	1.17	1.57	1.30	1.27	1.25	1.24	1.38	1.12	1.56	1.20	1.28			
	M	1.23	1.36	1.42	1.44	1.63	1.11	1.11	1.18	1.46	1.27	1.45			
	P-M	- 0.06	0.21	- 0.12	0.17	- 0.38	0.13	0.27	- 0.06	0.10	- 0.07	- 0.17			
Organic Sulfur, Percent	P	0.90	1.00	1.44	1.43	1.91	1.56	1.24	1.51	1.23	1.46	1.42			
	M	1.09	1.08	1.34	1.18	1.31	1.77	1.37	1.45	1.13	1.52	1.20			
	P-M	- 0.19	- 0.08	0.10	0.25	0.60	- 0.19	- 0.13	0.06	0.10	- 0.06	0.22			
Heating Value, Btu/lb	P	12,354	12,503	12,400	12,723	12,506	12,840	12,367	12,478	12,489	12,722	12,683			
	M	12,023	12,149	12,475	12,536	12,690	12,139	12,094	12,305	12,600	12,517	12,764			
	P-M	331	354	- 75	187	- 184	701	273	173	- 111	205	- 81			
Ash Content, Percent	P	14.92	14.24	12.51	12.56	12.28	12.43	14.26	13.74	13.21	13.10	12.77			
	M	14.97	13.50	12.92	12.80	9.29	11.41	14.43	13.38	13.50	13.00	13.60			
	P-M	- 0.05	0.74	- 0.41	- 0.24	2.99	1.02	- 0.17	0.36	- 0.29	0.10	- 0.83			
Total Moisture, Percent (As Rec'd)	P	8.82	6.03	12.86	6.31	5.56	4.66	4.68	5.82	5.53	5.58	5.63			
	M	9.78	7.87	7.34	6.72	6.72	6.70	6.09	5.82	7.19	6.60	6.10			
	P-M	- 0.96	- 1.84	5.52	- 0.41	- 1.16	- 2.04	- 1.41	0.00	- 1.66	- 1.02	- 0.47			
lbs SO ₂ per 10 ⁶ Btu	P	3.35	4.11	4.42	4.25	5.05	4.36	4.23	4.21	4.46	4.18	4.25			
	M	3.86	4.02	4.41	4.17	4.60	4.74	4.10	4.27	4.09	4.45	4.15			
	P-M	- 0.51	0.09	0.01	0.08	0.45	- 0.38	0.13	- 0.06	0.37	- 0.27	0.10			

P = Analytical Results, M = Calculated Mean, P-M = Difference between analytical results and calculated mean

TABLE 6-7
COMPARISON OF PHYSICAL AND MATHEMATICAL COMPOSITES
REPUBLIC PLANT, RAW COAL

Physical (P) Composites	Type Ident.	Daily Intervals							
		263	283	293	303	313	323	333	343
Mathematical Composites (M)	Type Ident. N	30-Minute Increments							
		263x 11	283x 14	293x 15	303x 6	313x 10	323x 14	333x 13	343x 11
Total	P	2.87	2.74	2.27	3.03	3.11	2.64	2.40	2.39
Sulfur,	M	2.69	2.49	2.68	2.53	2.72	2.70	2.48	2.87
Percent	P-M	0.18	0.25	-0.41	0.50	0.39	-0.06	-0.08	-0.48
Pyritic	P	1.89	1.69	1.42	1.77	1.89	1.58	1.62	1.60
Sulfur,	M	1.71	1.54	1.67	1.62	1.61	1.58	1.56	1.67
Percent	P-M	0.18	0.15	-0.25	0.15	0.28	0.00	0.06	-0.07
Organic	P	0.99	1.05	0.85	1.26	1.21	1.06	0.79	0.79
Sulfur,	M	0.98	0.95	1.01	0.91	1.11	1.12	0.92	1.20
Percent	P-M	0.01	0.10	-0.16	0.35	0.10	-0.06	-0.13	-0.41
Heating	P	10,691	10,609	9,977	10,517	10,451	10,521	10,204	9,381
Value,	M	9,898	9,831	9,807	10,190	10,257	9,738	10,130	9,960
Btu/lb	P-M	793	778	170	327	194	783	74	-579
Ash	P	28.63	28.76	32.38	26.82	29.02	36.33	31.41	37.17
Content,	M	33.60	33.70	33.17	34.09	30.89	33.91	30.99	32.82
Percent	P-M	-4.97	-4.94	-0.79	-7.27	-1.67	2.42	0.42	4.35
Total Moisture,	P	4.16	4.72	4.05	4.25	4.54	3.84	5.00	4.48
Percent	M	4.19	4.21	4.79	4.55	4.96	4.37	4.18	4.71
(As Rec'd)	P-M	-0.03	0.51	-0.74	-0.30	-0.62	-0.53	0.82	-0.23
lbs SO ₂	P	5.37	5.15	4.54	5.76	5.94	5.01	4.71	5.09
per	M	5.43	5.06	5.45	4.96	5.30	5.54	4.89	5.76
10 ⁶ Btu	P-M	-0.06	0.09	-0.92	0.80	0.64	-0.53	-0.18	-0.67

P = Analytical Results

M = Calculated Mean

P-M = Difference between analytical results and calculated mean

(Continued)

TABLE 6-7 (Continued)
COMPARISON OF PHYSICAL AND MATHEMATICAL COMPOSITES
REPUBLIC PLANT, RAW COAL

Physical (P) Composites	Type Ident.	Daily Intervals									
		213	223	233	243	253	353	363	373	383	393
Mathemat- ical Composites (M)	Type Ident.	One-Hour Increments									
		213x	223x	233x	243x	253x	353x	363x	373x	383x	393x
	M	5	6	7	5	7	3	7	7	8	8
Total Sulfur, Percent	P	2.40	2.52	2.64	2.95	2.52	2.43	2.37	2.47	2.40	2.64
	M	2.46	2.44	2.73	2.66	2.65	2.72	2.68	2.41	2.34	2.53
	P-M	-0.06	0.08	-0.09	0.29	-0.13	-0.29	-0.31	0.06	0.06	0.11
Pyritic Sulfur, Percent	P	1.27	1.51	1.56	1.82	1.56	1.31	1.43	1.36	1.60	1.66
	M	1.50	1.44	1.58	1.58	1.59	1.49	1.51	1.42	1.43	1.64
	P-M	-0.23	0.07	-0.02	0.24	-0.03	-0.18	-0.08	-0.06	0.17	0.02
Organic Sulfur, Percent	P	1.13	1.01	1.09	1.13	0.96	1.12	0.94	1.10	0.80	0.99
	M	0.96	1.00	1.15	1.08	1.06	1.23	1.17	0.99	0.91	0.89
	P-M	0.17	0.01	-0.06	0.05	-0.10	-0.11	-0.23	0.11	-0.11	0.10
Heating Value, Btu/lb	P	11,422	10,851	10,686	10,847	9,530	11,056	9,226	10,067	10,819	10,292
	M	10,138	10,359	10,446	9,371	10,466	9,991	9,443	9,739	10,148	10,482
	P-M	1,284	492	240	1,476	-936	1,065	-217	328	671	-190
Ash Content, Percent	P	24.76	48.11	28.51	29.38	36.55	25.85	32.46	31.62	27.19	30.81
	M	32.09	30.49	30.35	36.72	29.73	32.52	36.52	34.72	32.36	29.17
	P-M	-7.33	-2.38	-1.84	-7.34	6.82	-6.67	-4.06	-3.10	-5.17	1.64
Total Moisture, Percent (As Rec'd)	P	5.61	8.81	7.23	4.42	4.75	4.91	6.01	5.35	4.45	5.93
	M	5.42	4.33	5.53	4.54	4.54	5.36	5.69	5.70	4.48	5.60
	P-M	0.19	4.58	1.70	-0.12	0.21	-0.45	0.32	-0.35	-0.03	0.33
lbs SO ₂ per 10 ⁶ Btu	P	4.20	4.65	4.94	5.44	5.28	4.39	5.14	4.89	4.44	5.13
	M	4.85	4.71	5.22	5.67	5.06	5.44	5.67	4.94	4.61	4.82
	P-M	-0.65	-0.06	-0.28	-0.23	0.22	-1.05	-0.53	-0.05	-0.17	0.31

P = Analytical Results
M = Calculated Mean
P-M = Difference between analytical results and calculated mean

(Continued)

TABLE 6-7 (Continued)
COMPARISON OF PHYSICAL AND MATHEMATICAL COMPOSITES
REPUBLIC PLANT, RAW COAL

Physical (P) Composites	Type Ident.	Weekly			
		1	2	3	4
Mathematical Composites (M)	Type Ident. N	Daily			
		213-253 5	263-303 4	313-343 4	353-393 5
Total	P	2.45	3.25	2.83	2.67
Sulfur,	M	2.60	2.59	2.69	2.50
Percent	P-M	-0.15	0.66	0.14	0.17
Pyritic	P	1.72	2.14	1.67	1.46
Sulfur,	M	1.54	1.64	1.61	1.50
Percent	P-M	0.18	0.50	0.06	-0.04
Organic	P	0.73	1.11	1.16	1.21
Sulfur,	M	1.06	0.84	1.08	1.00
Percent	P-M	-0.33	0.26	0.08	0.21
Heating	P	9,859	10,026	10,547	10,510
Value,	M	10,223	9,897	10,015	9,972
Btu/lb	P-M	-364	129	532	538
Ash	P	33.32	37.71	28.97	29.98
Content,	M	31.46	33.49	32.15	33.04
Percent	P-M	1.86	4.22	-3.18	-3.06
Total Moisture,	P	4.88	4.46	4.40	4.70
Percent	M	4.88	4.45	4.56	5.34
(As Rec'd)	P-M	0.00	0.01	-0.16	-0.64
lbs SO ₂	P	4.97	6.48	5.36	5.08
per	M	5.08	5.23	5.37	5.01
10 ⁶ Btu	P-M	-0.11	1.25	-0.01	0.07

P = Analytical Results

M = Calculated Mean

P-M = Difference between analytical results and calculated mean

TABLE 6-8
COMPARISON OF PHYSICAL AND MATHEMATICAL COMPOSITES
REPUBLIC PLANT, CLEAN COAL

Physical (P) Composites	Type Ident.	Daily Intervals								
		264	274	284	294	304	314	324	334	344
Mathematical Composites (M)	Type Ident. N	30-Minute Increments								
		264x 10	274x 14	284x 13	294x 15	304x 10	314x 11	324x 14	334x 15	344x 13
Total Sulfur, Percent	P	1.22	1.22	1.28	1.36	1.29	1.24	1.25	1.14	1.13
	M	1.36	1.27	1.31	1.30	1.31	1.39	1.27	1.23	1.28
	P-M	-0.14	-0.15	-0.03	0.06	-0.02	-0.15	-0.02	-0.09	-0.15
Pyritic Sulfur, Percent	P	0.48	0.58	0.51	0.72	0.56	0.54	0.46	0.45	0.53
	M	0.53	0.57	0.56	0.62	0.59	0.53	0.45	0.49	0.48
	P-M	-0.05	0.01	-0.05	0.10	-0.03	-0.01	-0.02	-0.04	0.05
Organic Sulfur, Percent	P	0.75	0.64	0.78	0.63	0.73	0.70	0.78	0.70	0.59
	M	0.83	0.70	0.75	0.68	0.72	0.84	0.79	0.74	0.80
	P-M	-0.08	-0.06	0.03	-0.05	0.01	0.06	-0.01	-0.04	-0.21
Heating Value, Btu/lb	P	14,141	14,090	13,818	13,608	13,678	14,140	14,109	14,026	14,002
	M	14,097	13,923	13,932	13,987	13,900	13,990	14,034	13,986	13,926
	P-M	44	167	-114	-379	-222	150	75	40	76
Ash Content, Percent	P	8.51	8.61	9.25	10.11	9.02	8.44	8.81	8.63	9.30
	M	9.02	9.17	9.48	9.56	8.82	8.87	8.85	9.16	9.21
	P-M	-0.51	-0.56	-0.23	0.55	0.20	-0.43	-0.04	-0.53	0.09
Total Moisture, Percent (As Rec'd)	P	8.51	8.82	6.35	5.87	9.48	8.73	8.90	6.49	5.78
	M	8.18	7.49	6.48	5.85	6.92	8.88	9.49	6.15	6.15
	P-M	0.33	1.33	-0.13	0.02	2.56	-0.15	-0.59	0.34	-0.37
lbs SO ₂ per 10 ⁶ Btu	P	1.73	1.73	1.86	1.99	1.88	1.75	1.77	1.63	1.61
	M	1.93	1.82	1.88	1.86	1.88	1.99	1.81	1.76	1.84
	P-M	-0.20	-0.09	-0.02	0.13	0.00	-0.24	-0.04	-0.13	-0.23

P = Analytical Results

M = Calculated Mean

P-M = Difference between analytical results and calculated mean

(Continued)

TABLE 6-8 (Continued)
COMPARISON OF PHYSICAL AND MATHEMATICAL COMPOSITES
REPUBLIC PLANT, CLEAN COAL

Physical (P) Composites	Type Ident.	Daily Intervals									
		214	224	234	244	254	354	364	374	384	394
Mathemat- ical Composites (M)	Type Ident. N	One-Hour Increments									
		214x	224x	234x	244x	254x	354x	364x	374x	384x	394x
		2	6	7	6	7	6	7	8	8	8
Total	P	1.34	1.35	1.33	1.29	1.42	1.45	1.38	1.24	1.25	1.29
Sulfur,	M	1.31	1.42	1.38	1.29	1.34	1.40	1.27	1.21	1.28	1.27
Percent	P-M	0.03	-0.07	-0.05	0.00	0.08	0.05	0.11	0.03	-0.03	0.02
Pyritic	P	0.65	0.66	0.63	0.53	0.57	0.59	0.57	0.59	0.65	0.58
Sulfur,	M	0.64	0.62	0.58	0.52	0.54	0.63	0.51	0.55	0.63	0.51
Percent	P-M	0.01	0.04	0.05	0.01	0.03	-0.04	0.06	0.04	0.02	0.07
Organic	P	0.68	0.69	0.70	0.76	0.84	0.86	0.81	0.65	0.61	0.70
Sulfur,	M	0.67	0.80	0.80	0.77	0.80	0.77	0.76	0.66	0.65	0.76
Percent	P-M	0.01	-0.11	-0.10	-0.01	0.04	0.09	0.05	-0.01	-0.04	-0.06
Heating	P	13,920	13,881	13,739	14,024	13,544	13,827	14,016	13,709	13,977	14,055
Value,	M	13,714	13,851	13,965	14,057	13,979	13,658	13,992	14,019	14,053	13,945
Btu/lb	P-M	206	30	-226	-33	-435	169	24	-310	-76	110
Ash	P	10.12	9.89	10.92	9.10	8.85	9.80	9.76	9.29	9.41	8.91
Content,	M	10.77	10.25	9.39	9.01	9.45	10.36	10.30	9.35	9.19	8.75
Percent	P-M	-0.65	0.36	1.53	0.09	-0.60	-0.56	-0.54	-0.06	0.22	0.16
Total	P	8.64	8.27	5.52	7.95	7.68	12.20	5.35	4.82	6.57	7.70
Moisture,	M	8.74	8.10	7.51	7.82	7.66	7.50	5.68	5.52	6.25	7.62
Percent (As Rec'd)	P-M	-0.10	0.17	-1.99	0.13	0.02	4.70	-0.33	-0.70	0.32	0.08
lbs SO ₂	P	1.92	1.94	1.93	1.84	2.09	2.10	1.97	1.81	1.79	1.83
per	M	1.91	2.05	1.97	1.83	1.92	2.05	1.81	1.72	1.82	1.82
10 ⁶ Btu	P-M	0.01	0.11	-0.04	0.01	0.17	0.05	0.16	0.09	-0.03	0.01

P = Analytical Results

M = Calculated Mean

P-M = Difference between analytical results and calculated mean

(Continued)

TABLE 6-8 (Continued)
COMPARISON OF PHYSICAL AND MATHEMATICAL COMPOSITES
REPUBLIC PLANT, CLEAN COAL

Physical (P) Composites	Type Ident.	Weekly			
		1	2	3	4
Mathematical Composites (M)	Type Ident. N	Daily			
		214-254 5	264-304 5	314-344 4	354-394 5
Total	P	1.46	1.25	1.18	1.34
Sulfur,	M	1.36	1.30	1.29	1.28
Percent	P-M	0.01	-0.05	-0.11	0.06
Pyritic	P	0.69	0.55	0.44	0.52
Sulfur,	M	0.57	0.58	0.50	0.56
Percent	P-M	0.12	-0.03	-0.06	-0.04
Organic	P	0.77	0.70	0.74	0.82
Sulfur,	M	0.79	0.72	0.79	0.72
Percent	P-M	-0.02	-0.02	-0.05	0.10
Heating	P	13,989	14,095	13,982	13,941
Value,	M	13,943	13,965	13,987	13,960
Btu/lb	P-M	46	130	-5	-19
Ash	P	9.65	8.99	8.83	9.54
Content,	M	9.62	9.25	9.02	9.47
Percent	P-M	0.03	-0.26	-0.19	0.07
Total Moisture,	P	7.26	7.17	6.55	7.30
Percent	M	7.82	6.93	7.68	6.46
(As Rec'd)	P-M	-0.56	0.24	1.13	0.84
lbs SO ₂	P	2.09	1.77	1.69	1.92
per	M	1.95	1.86	1.84	1.83
10 ⁶ Btu	P-M	0.14	-0.09	-0.15	-0.11

P = Analytical Results

M = Calculated Mean

P-M - Difference between analytical results and calculated mean

TABLE 6-9. VARIANCE FOR PHYSICAL COMPOSITING

	R&F PLANT				REPUBLIC PLANT			
	Raw Coals ($\sum N = 147$)		Clean Coals ($\sum N = 132$)		Raw Coals ($\sum N = 175$)		Clean Coals ($\sum N = 199$)	
	S^2_C	S_C	RSD _C	S^2_C	S_C	RSD _C	S^2_C	RSD _C
Total Sulfur	0.0224	0.1496	0.046	0.0101	0.1005	0.048	0.00399	0.0632
Pyritic Sulfur	0.0441	0.2100	0.114	0.0192	0.1385	0.106	0.00127	0.0396
Organic Sulfur	0.0309	0.1757	0.142	0.0322	0.1794	0.137	0.00285	0.0533
Heating Value	19,149	138.4	0.012	50,038	223.7	0.018	16,620	128.9
Ash Content	0.964	0.982	0.048	0.638	0.799	0.062	0.1121	0.339
Total Moisture	0.757	0.870	0.121	2.532	1.591	0.223	0.696	0.834
lbs SO ₂ /10 ⁶ Btu	0.0617	0.2483	0.045	0.0391	0.1979	0.047	0.00807	0.0898

The relative standard deviations (RSDs) for the raw Republic coals are generally higher than for the raw R&F coals, but the RSDs for clean coal are about equal for the two plants.

SUMMARY OF MEASUREMENT UNCERTAINTIES

Table 6-10 summarizes the various independent estimates of measurement uncertainty for total sulfur, ash content, and heating value. Also shown in Table 6-10, for each parameter, are the total observed variations from Table 5-7 (Data Sets III and VII).

The compositing uncertainties are understandably larger than the others, since the procedure for determining coal characteristics of composited samples includes sample preparation and laboratory analysis as well as sample splitting and compositing. The large compositing uncertainties could be a problem for determining long term emissions using coal sampling compliance methods.

However, all values for measurement uncertainty on Table 6-10 are significantly less than the total observed variations in coal characteristics. The conclusion, therefore, is that real variations in coal properties do exist, over and above the measurement noise level.

TABLE 6-10. SUMMARY OF MEASUREMENT UNCERTAINTIES AND TOTAL COAL VARIATION

		Raw Coals		Clean Coals	
		S	RSD	S	RSD
TOTAL SULFUR	ASTM Criteria	0.177	0.049	0.106	0.071
	Historical Data	0.037	0.019	0.010	0.006
	Pretesting Verification	0.063	0.032	ND*	ND
	Redundant Tests - R&F	0.065	0.023	0.062	0.026
	Redundant Tests - Republic	0.085	0.052	0.068	0.040
	Physical Compositing - R&F	0.150	0.049	0.101	0.038
	Physical Compositing - Republic	0.195	0.076	0.063	0.048
	Total Variation - R&F	0.441	0.143	0.286	0.109
	Total Variation - Republic	0.317	0.123	0.085	0.065
ASH CONTENT	ASTM Criteria	0.71	0.059	0.71	0.059
	Historical Data	0.25	0.017	0.10	0.017
	Pretesting Verification	0.49	0.022	ND	ND
	Redundant Tests - R&F	0.18	0.009	0.15	0.011
	Redundant Tests - Republic	0.29	0.009	0.16	0.018
	Physical Compositing - R&F	0.98	0.048	0.80	0.062
	Physical Compositing - Republic	1.88	0.089	0.34	0.036
	Total Variation - R&F	2.64	0.130	2.16	0.168
	Total Variation - Republic	5.44	0.168	0.78	0.083
HEATING VALUE	ASTM Criteria	71	0.006	71	0.006
	Pretesting Verification	105	0.009	ND	ND
	Redundant Tests - R&F	75	0.006	77	0.006
	Redundant Tests - Republic	82	0.008	76	0.005
	Physical Compositing - R&F	138	0.012	224	0.018
	Physical Compositing - Republic	441	0.044	129	0.009
	Total Variation - R&F	370	0.033	318	0.026
	Total Variation - Republic	880	0.087	172	0.012

* Not determined.

SECTION 7.0

PRELIMINARY ANALYSIS FOR THE COMPONENTS OF VARIABILITY

One approach to characterizing variability in coal is to relate measured coal properties to the geologic history and current geologic characteristics of the deposit. Included in this approach is the documentation of the precise mining location for each lot of coal sampled and analyzed and the correlation of sulfur and heating value data to the impurities in coal. These subjects are currently under study by the U.S. Geological Survey.

An alternative approach, taken in this study, is to characterize sulfur variability from existing coal analysis data itself. This approach is empirical, compared to the more fundamental approach described above. The ultimate objective, however, is the same: to be able to predict with some precision the variability of each coal resource, and further, to find ways to attenuate or accommodate this variability.

The total variance, V_{total} , represents the variability about the mean of the data points within each data set. Values for V_{total} were presented in Section 5.0. To examine the reasons for variability in coal, the functional components of variability must be quantified. Part of the total variance in coal data is attributable to the process of acquiring the data -- estimates for the uncertainties in measured data were presented in Section 6.0. Because the values for measurement uncertainty were significantly less than the total observed variations in coal characteristics, it was concluded that true variations in coal properties existed.

This section provides an evaluation of other components of variability, including those attributable to coal source, lot size, and the randomness and autocorrelation of the coal. Evaluation of these components of variability

is applicable to each data set individually. Different values of V_{total} will therefore exist for raw and clean coals, and for each plant.

No attempt has been made in this study to evaluate additional geographic and source-specific components of variance. The sulfur level and its variability are unique according to the region and the seam of the deposit, and to the particular mine and mining method. Additional differences exist among coal preparation methods employed. While the comparison of V_{total} values between R&F and Republic, and between raw and cleaned coal at each of the plants, may provide some indication of this additional variability among data sets, there are insufficient data sets available to define quantitative and generally applicable values for this geographic and source-specific component of variability.

V_{source} is the component of variance that accounts for differences of the source of the coal. Included are coal characteristics influenced by the coal seam, the coal mine, the mining methods employed, any preliminary preparation employed at the mine, the blending effects during mine shipping, transportation, receiving at the coal cleaning plant, and storage and handling at the plant. The coal fed to the R&F cleaning plant is from three different seams, and the variance component V_{source} is intended to quantify the contribution to variability (in both raw and clean coal) from source differences. Conversely, the coal fed to the Republic cleaning plant is from a single seam and a single mine. For this plant, V_{source} should be relatively low.

Calculations of S^2 pooled showed that the variances for seam-grouped data were less than for mixed data, but this was found to be true for other groupings of the data also. For example, pooled variances for R&F Data Sets I and II in Table 5-7 (grouped by sampling period rather than stock-pile) were as small as the seam-grouped data variances. Also, the variances for "pure-seam" stockpiles were no smaller than those from "blended-seam" stockpiles. Thus, a variance for V_{source} could not be quantified.

V_{lot} size is the component of variance in reported coal data that accounts for higher variability among smaller lots than among larger lots. Intuitively, one would expect smaller tonnage lots to be individually more uniform, but to differ from each other. On the other hand, very large tonnage lots should each contain many modules of coal with properties different from one another, but with a mean for each lot nearer the average for the entire coal deposit. Therefore, larger lots should display means that deviate less from each other, and consequently have a lower variance, than small lots. The expectation for an inverse relationship of lot size and variance also derives support from the Central Limit Theorem of conventional statistics.

The remaining two components of variance, V_{random} and $V_{correlated}$, together account for the fundamental variability of coal from the same source. Previously-described terms (other than V_{source}) accounted for errors introduced into the data by the process of acquiring the data. V_{random} and $V_{correlated}$, however, are components of variability for the coal itself. They measure the real phenomenon that coal lots from the same source and from the same coal preparation plant do indeed differ from one another.

Because the lot-to-lot variation in coal has previously been shown to exhibit autocorrelation, two components of variance have been included in the model. V_{random} is defined as the independent component of coal variance, and $V_{correlated}$ as the component of coal variance responsible for serial dependencies. The analysis in this section shows that the data are autocorrelated, (i.e., that there are serial dependencies). Two approaches are subsequently presented for analyzing serial dependencies -- a geostatistical approach, in Section 8.0, and a time-series approach, in Section 9.0.

It is not known to what extent geological trends are preserved from mine to preparation plant, but some carry-over is expected. At least a portion of the spatial correlation in the mine should be discernible as temporal correlation at the plant. Thus, a geostatistical analysis was

applied, and the components of total variance were evaluated in terms of a time series at the preparation plants.

VARIANCE FOR DIFFERENT COAL LOT SIZES

At each of the two preparation plants, discrete full-stream primary samples are physically composited in several stages. At the R & F plant, primary full-stream samples of both raw coal and product coal were acquired every six minutes. Five consecutive primary samples were then physically composited to generate a 30-minute increment sample. One subsample of this 30-minute composite was analyzed (in duplicate) in portions of the study. Another subsample was reserved along with 15 other consecutive 30-minute increment samples to form an 8-hour physical composite. Still other subsamples of the 30-minute increment composites were reserved to form daily, weekly, and monthly physical composites.

Physical composites are automatically flow-proportioned. The quantity of coal in each primary full-stream sample is proportional to the throughput, since the sampling time is held constant. The 30-minute increment samples are the full quantity of the five consecutive primary samples, and so are flow-proportioned. Aliquots reserved for daily, weekly, and monthly composite samples are always a constant fraction of the total sample, rather than a constant quantity of material.

A similar procedure is used at the Republic plant, except that each 30-minute or one-hour incremental sample is itself a single primary full-stream sample (rather than a composite of several primary samples as is the case at the R & F plant).

Alternate results for daily, weekly, and monthly coal characteristics may be generated by mathematically compositing the experimental 30-minute, 1-hour, or 8-hour incremental data. At the R & F plant, flowrate data were not available, so the mathematical composite results are time-averaged. Conversely, the mathematical composite results for the Republic plant are flow-proportioned.

Effect of Lot Size

Several data sets, differing in the time interval for each sample, were determined at each of the two coal preparation plants. These time intervals are translatable into average lot sizes which each composite sample represents, as shown in Table 7-1.

The relative standard deviations (RSDs) from Table 5-7, for the data sets of 30-minute and one-hour increments, are summarized in Table 7-1. For the 8-hour, daily, and weekly composites, the RSDs in Table 7-1 are those determined from the mathematical composites in Tables 6-5 through 6-8. Also listed in Table 7-1 are the composite uncertainty--i.e., $V_{\text{composite}}$ values of RSDs,--derived in the previous section by comparing physical and mathematical composites. The RSDs were normalized in Table 7-1 by dividing by the appropriate "uncertainty" RSD.

Inspection of Table 7-1 demonstrates that in almost every case, the relative standard deviation decreases with increasing lot size. In addition, at one week the RSD is essentially equal to the measurement uncertainty, indicating that true measures of variability in the coal are lost by using lot sizes greater than one week. The relationships between the normalized RSD (RSD/uncertainty) and lot size were analyzed by the "least squares" method and are shown in Figures 7-1 for raw coals and 7-2 for clean coals. The least-square lines have the following characteristics:

	Slope	Value of Normalized RSD at 10,000 Tons	Correlation Coefficient
R & F, Raw Coal	-0.991	1.567	-0.974
Republic, Raw Coal	-0.927	0.672	-0.965
R & F, Clean Coal	-0.735	1.392	-0.778
Republic, Clean Coal	-0.581	0.709	-0.787

The two raw coal curves on Figure 7-1 have almost equivalent slopes, but the R & F line is above the Republic line. The raw coal data from both

TABLE 7-1. RELATIVE STANDARD DEVIATIONS FOR DIFFERENT LOT SIZES

Data Set	Time Intv.	Lot Size Tons	Relative Standard Deviation							Relative Standard Deviation/Uncertainty						
			TS	PS	OS	IV	Ash	Mois.	lb SO ₂ /10 ⁶ Btu	TS	PS	OS	IV	Ash	Mois.	lb SO ₂ /10 ⁶ Btu
R&F Raw Coal	III	492	0.143	0.227	0.259	0.033	0.130	0.150	0.137	2.92	1.99	1.82	2.75	2.71	1.24	3.04
	IV	7,872	0.088	0.170	0.126	0.018	0.081	0.107	0.079	1.80	1.49	0.89	1.50	1.69	0.88	1.76
	V	62,635	0.018	0.111	0.150	0.013	0.049	0.095	0.027	0.37	0.97	1.06	1.08	1.02	0.79	0.60
	Uncertainty*		0.049	0.114	0.142	0.012	0.048	0.121	0.045							
	III	379	0.109	0.166	0.210	0.026	0.168	0.295	0.102	2.87	1.57	1.53	1.44	2.71	1.32	2.17
R&F Clean Coal	IV	6,064	0.088	0.143	0.181	0.021	0.150	0.167	0.075	2.32	1.35	1.32	1.17	2.42	0.75	1.60
	V	48,370	0.033	0.103	0.143	0.015	0.020	0.094	0.037	0.87	0.97	1.04	0.83	0.32	0.42	0.79
	Uncertainty		0.038	0.106	0.137	0.018	0.062	0.223	0.047							
	VI	399	0.128	0.155	0.209	0.088	0.158	0.156	0.160	1.68	2.07	1.66	2.00	1.76	1.03	2.25
	VII	797	0.123	0.140	0.193	0.087	0.168	0.216	0.126	1.62	1.87	1.53	1.98	1.89	1.43	1.77
Republic Raw Coal	VIII	5,107	0.055	0.055	0.104	0.033	0.066	0.245	0.069	0.72	0.73	0.83	0.75	0.74	1.62	0.97
	IX	25,533	0.030	0.041	0.104	0.014	0.028	0.083	0.031	0.39	0.55	0.83	0.32	0.31	0.55	0.44
	Uncertainty		0.076	0.075	0.126	0.044	0.089	0.151	0.071							
	VI	229	0.065	0.133	0.100	0.014	0.062	0.305	0.070	1.35	2.08	1.41	1.52	1.72	2.63	1.46
	VII	458	0.065	0.130	0.096	0.012	0.083	0.301	0.070	1.35	2.03	1.35	1.34	2.31	2.59	1.46
Republic Clean Coal	VIII	2,933	0.044	0.095	0.077	0.0079	0.062	0.158	0.048	0.92	1.48	1.08	0.86	1.72	1.36	1.00
	IX	14,663	0.028	0.065	0.054	0.0013	0.028	0.089	0.029	0.58	1.02	0.76	0.14	0.78	0.77	0.60
	Uncertainty		0.048	0.064	0.071	0.0092	0.036	0.116	0.048							

* V composite

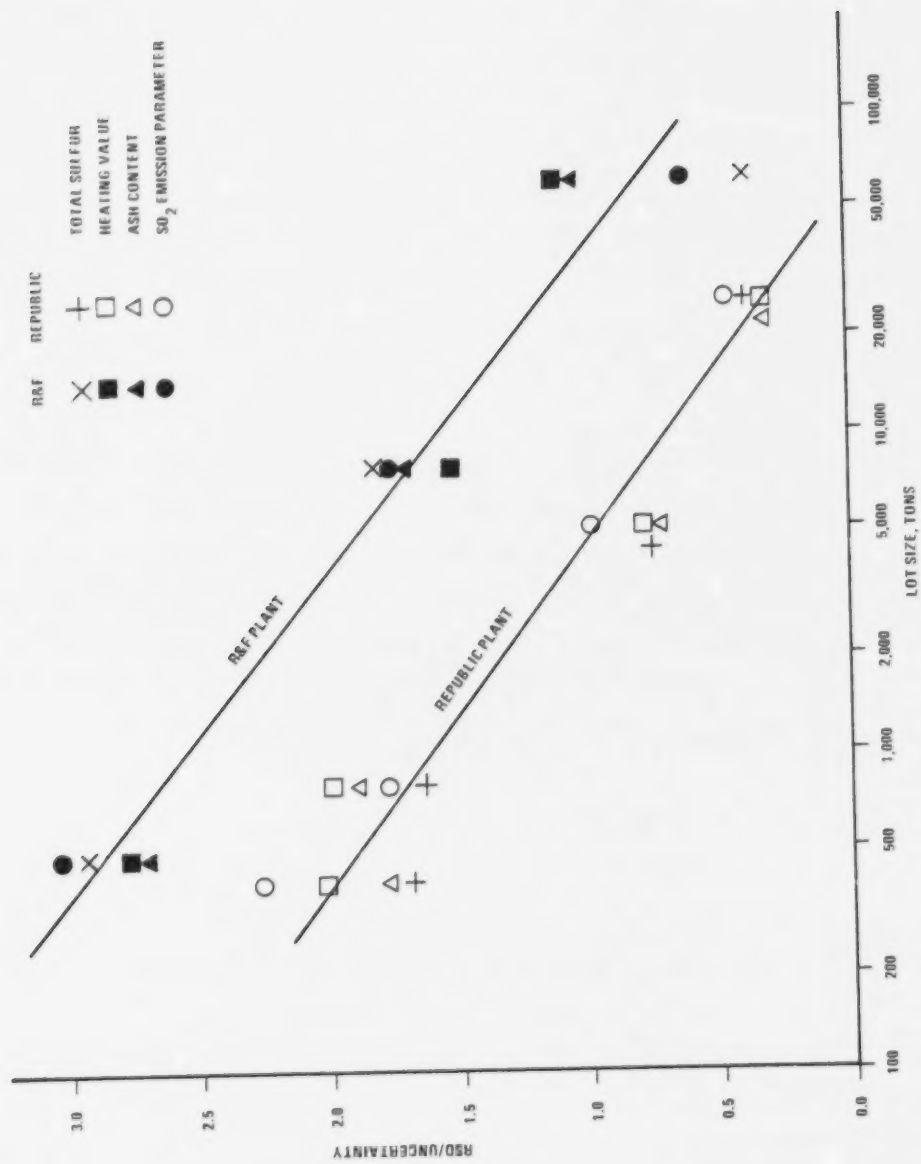


Figure 7-1. Effect of Lot Size Upon Normalized RSD for Raw Coals.

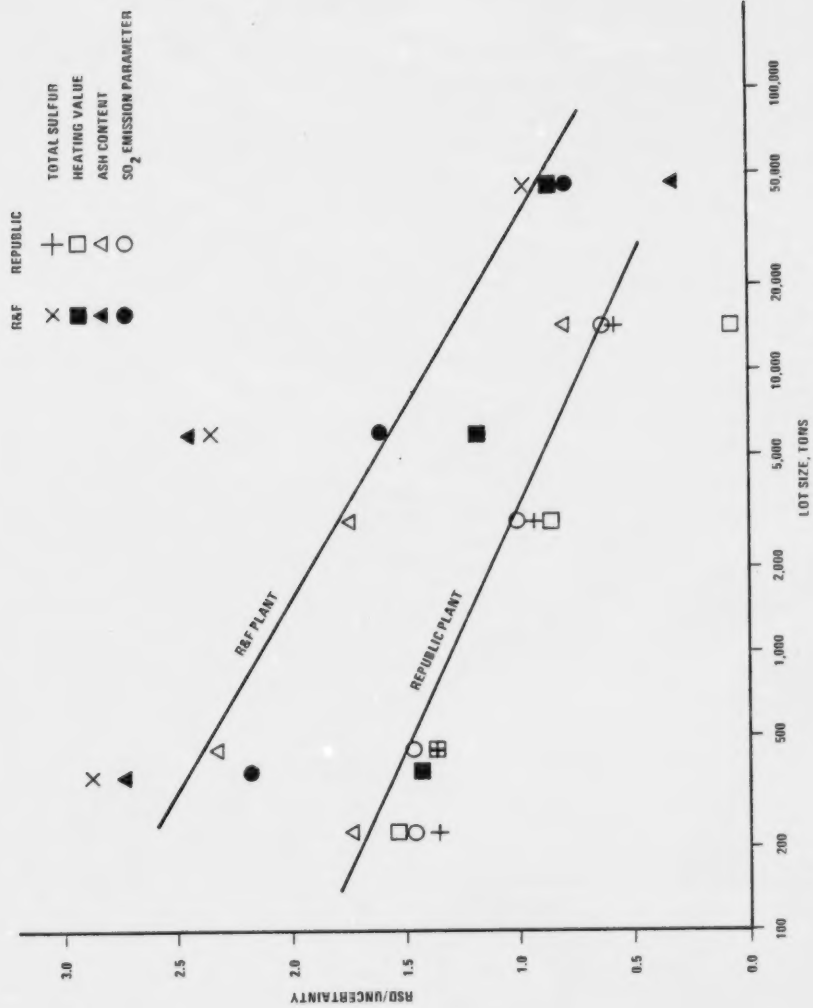


Figure 7-2. Effect of Lot Size Upon Normalized RSD for Clean Coals.

plants are highly correlated, with values for the correlation coefficient* close to unity.

Similarly, the two clean coal lines on Figure 7-2 are approximately parallel, but again the R & F line is above the Republic line. These slopes of the clean coal functions are not as steep as the raw coal lines on Figure 7-1. The clean coal data are characterized by more scatter than the raw coal lines.

If the values for the slopes, given above, are multiplied by the appropriate values for the uncertainty in $\text{lbs SO}_2/10^6 \text{ Btu}$, the results are slopes for non-normalized RSD lines for this parameter:

	<u>Slope</u>
R & F, Raw Coal	-0.045
Republic, Raw Coal	-0.066
R & F, Clean Coal	-0.035
Republic, Clean Coal	-0.028

In comparison, a value of -0.0223 was derived in a previous Versar study of data sets (including both raw and clean coal) acquired from coal cleaning plants.⁽¹⁾

RANDOM AND CORRELATED VARIANCE

Correlation vs. Randomness in Coal Data

Coal originated from the deposition of plant materials in swampy areas at various time intervals from 50 to 350 million years ago. These depositions have resulted in more or less horizontal strata which we denote as seams. Subsequent geological activities have distorted these layers to varying degrees. The thickness of seams varies from several inches to several hundred feet. The coal qualities vary widely from seam to seam.

* Used in the sense applied to least-squares analyses.

Although coals within a given seam are more consistent in their properties than coals from different seams, substantial variations in coal property exist within a seam both vertically and horizontally. For example, the distribution of sulfur contents exhibits a mixed character, being partly structured and partly random. There are concentrations of high sulfur areas and low sulfur areas. The structural continuity is related to the organic sulfur in the coal matrix, while the randomness may be attributed to discrete particles in the form of pyrite. Thus a scientific estimation of coal reserve must take into account both structure and randomness.

A basic assumption often used in statistical evaluation of data is that all sample values are independent of each other. A good example of this type of analysis is tossing a coin. The outcome of either head or tail is completely independent and is not correlated.

As revealed by the discussion of coal formation above, this assumption of independence is invalid for coal seams. It is more reasonable to expect that sample values at a point in a seam are correlated to the sample values of its neighboring points and the extent of correlation depends on the distance and direction relative to the seam. Autocorrelation of coal data was examined in the prior Versar study in which Crow's test for autocorrelation was applied to 50 data sets.⁽¹⁾ The autocorrelation test gave positive results in 6 of 25 unwashed coal data sets and in 10 of 25 washed coal data sets, at the 95 percent confidence level. Of these 16 data sets giving positive results, 9 were positive at the 99 percent confidence level, and 4 were positive at the 99.9 percent confidence level.

Tests for Autocorrelation of Data

One method for detecting a trend in data (an autocorrelation) is given by Crow.⁽⁶⁾ The mean square successive difference δ^2 is calculated by:

$$\frac{1}{N} \sum_{i=1}^N [Z(x_i + 1) - (x_i)]^2$$

An estimate of the component of variance that reduces the trend effect is

$\delta^2/2$, which is the same as the estimate of the "nugget" variance in the geostatistical approach of Section 8. Crow's test for autocorrelation consists of computing δ^2/S^2 (which is equal to $2\gamma(1)/S^2$). If the data are not serially correlated, a value of δ^2/S^2 near 2 is expected. Values of δ^2/S^2 less than 2 occur with autocorrelation, and values greater than 2 occur with serial oscillation greater than random variation⁽¹⁾.

The data sets of Table 7-2 were tested by Crow's method. Table 7-2 lists, for total sulfur, heating value, ash content, and emission rate, values of $\gamma(1) = \delta^2/2$, and of the ratio of δ^2/S^2 . The appropriate critical values (at the 95 percent confidence level) are also listed, and those data sets meeting the test for autocorrelation or for rapid oscillation are noted by an asterisk. A double asterisk signifies that the test was positive at the 99 percent confidence level, and a triple asterisk refers to a positive test result at 99.9 percent confidence.

By inspection of Table 7-2, the R & F raw coal data sets of samples for 30-minute increments (Data Sets I, II, and III) consist of highly-autocorrelated data, for all four parameters. The corresponding clean coal data, especially for Data Sets II and III, are also autocorrelated.

The 8-hour physical composites for R & F raw coal, Data Set IV, exhibited strong autocorrelation only for heating value and for ash. The corresponding clean coal data exhibited weaker autocorrelation. The weekly R & F composites (Data Set V), consisting of only four points, did not exhibit consistently-strong autocorrelation. Decreasing autocorrelation as the sample time increment increases from 30 minutes to 8 hours and up to one week would be expected if the geological trends have periods (in terms of cleaning plant operating time) shorter than 8 hours.

Inspection of the Republic plant Data Sets in Table 7-2 shows that the raw coal exhibits less autocorrelation than the R & F raw coal. This result is contrary to expectations, since the Republic coal is from a single deep mine and geological trends should have been preserved. In contrast, geological trends would be expected to be obscured by blending at

TABLE 7-2. AUTOCORRELATION TEST

Data Set	Parameter	Raw Coals					Clean Coals				
		$(\delta^2/S^2) .95$	$\gamma(1) = \frac{\delta^2}{2}$	S	δ^2/S^2	Confidence	$(\delta^2/S^2) .95$	$\gamma(1) = \frac{\delta^2}{2}$	S	δ^2/S^2	Confidence
R&F I 4/29-4/30 30-Min.	TS	1.515	0.0155	0.212	0.690	***	1.498	0.00845	0.106	1.504	
	HV	N=44	9,660	152	0.836	***	N=41	31,106	218	1.309	*
	Ash		0.728	2.197	0.302	***		0.204	0.922	0.480	***
	E		0.0538	0.403	0.663	***		0.0242	0.169	1.695	
R&F II 5/19-5/23 30-Min.	TS	1.625	0.130	0.442	1.331	**	1.635	0.0362	0.281	0.917	***
	HV	N=74	114,944	434	1.220	***	N=78	55,182	345	0.927	***
	Ash		3.847	2.870	0.934	***		1.602	2.338	0.586	***
	E		0.464	0.802	1.443	**		0.103	0.441	1.059	***
R&F III 4/29-5/23 30-Min.	TS	1.699	0.0870	0.441	0.895	***	1.700	0.0266	0.286	0.650	***
	HV	N=118	75,581	370	1.104	***	N=119	46,565	318	0.921	***
	Ash		2.669	2.638	0.767	***		1.137	2.159	0.488	***
	E		0.310	0.748	1.108	***		0.0756	0.433	0.806	***
R&F IV 8-Hour	TS	1.435	0.0721	0.291	1.703		1.443	0.0354	0.206	1.668	
	HV	N=32	44,931	302	0.985	***	N=33	71,982	314	1.460	
	Ash		0.711	1.384	0.742	***		0.834	1.108	1.359	*
	E		0.264	0.526	1.908			0.1003	0.331	1.831	
R&F V Weekly	TS	0.781	0.0156	0.085	4.318		0.781	0.00735	0.070	3.000	
	HV	N=4	14,334	198	0.731	*	N=4	9,322	128	1.138	
	Ash		1.647	1.176	2.382			0.0670	0.403	0.825	
	E		0.0574	0.343	0.976			0.0243	0.127	3.013	
Republic VI 30-Min.	TS	1.694	0.1094	0.339	1.904		1.701	0.00489	0.085	1.354	***
	HV	N=113	758,811	874	1.987		N=120	29,186	196	1.519	**
	Ash		26.255	5.201	1.941			0.196	0.572	1.198	***
	E		0.716	0.857	1.950			0.0118	0.131	1.375	***
Republic VII 1-Hour	TS	1.704	0.0805	0.317	1.602	*	1.710	0.00488	0.085	1.351	***
	HV	N=123	650,651	880	1.680	*	N=129	22,695	172	1.528	**
	Ash		22.000	5.435	1.490	**		0.287	0.780	0.943	***
	E		0.412	0.647	1.968			0.0113	0.131	1.317	***
Republic VIII Daily	TS	1.266	0.0501	0.249	1.616		1.283	0.00583	0.083	1.693	
	HV	N=18	395,072	585	2.309		N=19	35,423	185	2.070	
	Ash		15.357	3.620	2.344			0.239	0.656	1.111	*
	E		0.168	0.467	1.541			0.0156	0.135	1.712	
Republic IX Weekly	TS	0.781	0.1403	0.338	2.456		0.781	0.01243	0.121	1.698	
	HV	N=4	50,117	346	0.837		N=4	4,281	66	1.966	
	Ash		16.113	3.942	2.074			0.1609	0.403	1.981	
	E		0.602	0.691	2.522			0.0270	0.175	1.763	

*95% Confidence Level

**99% Confidence Level

***99.9% Confidence Level

the R & F plant, where the raw coal is derived from three seams and from many individual mines (a majority of which were strip mines). The 30-minute increment data for Republic raw coal (Data Set VI) exhibits very little autocorrelation, and the one-hour data for Republic raw coal (Data Set VII) exhibits weaker autocorrelation than the R & F raw coal.

In contrast to the Republic raw coal, both the 30-minute and one-hour Data Sets (VI and VII) for Republic clean coal consist of highly autocorrelated data for all four coal characteristics. This is understandable in light of the fact that the measurement uncertainty or white noise variance is smaller for clean coals than for raw coals. Thus, autocorrelation is more clearly seen in the clean coal.

The daily and weekly clean coal composite samples from the Republic plant (Data Sets VIII and IX) resulted in data not nearly as autocorrelated as the 30-minute and one-hour data. This is expected if geological trend periods and/or cleaning plant performance trend periods are shorter in time than one day.

The overall conclusion of this preliminary analysis is that serial correlation of coal data does in fact exist. The following two sections attempt to quantify the correlated and random components of the variability in coal. Section 8 addresses a geostatistical approach, and Section 9 addresses a time-series approach.

SECTION 8.0

GEOSTATISTICAL ANALYSIS

The positive test for serial correlation in Section 7 leads to the use of geostatistics as one of two approaches to quantify random and correlated components of variance in coal data. The discussion in Section 7 also addressed the structural continuity of coal data from the perspective of geology. The spatial structural continuity from the coal mine is somewhat preserved during transport and handling of the coal and is transformed into the temporal continuity in the coal feed entering the preparation plant. Therefore, the use of geostatistics will model a one dimensional variation in time.

DESCRIPTION OF GEOSTATISTICS

The following description of geostatistics is very brief. Interested readers are referred to the book entitled Mining Geostatistics by Journel and Huijbregts.⁽⁷⁾

Experimental Semi-Variogram

A good measure of the structural continuity is the difference in sample values between two neighboring points in the seam. Intuitively, if the neighboring sample values are similar, the differences are small, and structural continuity exists. If the neighboring sample values are dissimilar, the differences are larger and there is little or no structural continuity. One way to characterize structural continuity is to express the variance of sample value differences rather than individual differences as a function of distance and direction (vector distance). The variance of the difference in sample values as a function of distance is defined as the semi-variogram. A semi-variogram can be constructed by using a finite number of sample values:

$$\gamma^*(r) = \frac{1}{2 N(r)} \sum_{i=1}^{N(r)} [Z(x_i + r) - Z(x_i)]^2$$

Note that r represents a vectorial distance and specifies both distance and direction.

Another interpretation of the experimental semi-variogram is the error in estimation that would result by substituting the sample values for those of neighboring points. The errors in estimation will be large if the sample values are dissimilar, and vice versa.

Determination of Random Variance and Correlated Variance--

If the semi-variogram is calculated for a sufficient number of points, a graph can be constructed of $\gamma^*(r)$ vs. r as in Figure 8-1. It is expected that the semi-variogram values will be small if there is structural continuity, and vice versa. Of the two curves shown, the top curve has a smaller range of influence "a" (beyond which much of the structural continuity is lost) and a larger maximum value of $\gamma^*(r)$, called the sill value ($C_0 + C$). In general, the semi-variogram does not pass through the origin; rather, it intersects the ordinate at a value C_0 , called the nugget constant. This non-zero constant is attributed to the structural discontinuity. The nugget constant represents the random variance. The difference between the sill value and nugget constant represents the correlated variance.

The lower curve in Figure 8-1 exhibits similar features, but with a larger range of influence and smaller sill value and nugget constant. The comparison of two curves shows that the lower curve has less variability and stronger structural continuity.

Geostatistical Analysis - R&F Coal Company

This section discusses the geostatistical analysis of R&F Coal Company's data. The sources of these data include (1) Versar's sampling and analysis of ROM coal and clean coal (total sulfur, pyritic sulfur, ash, heating value) and (2) R&F Coal Company's measured data of clean coal (total sulfur, ash, heating value).

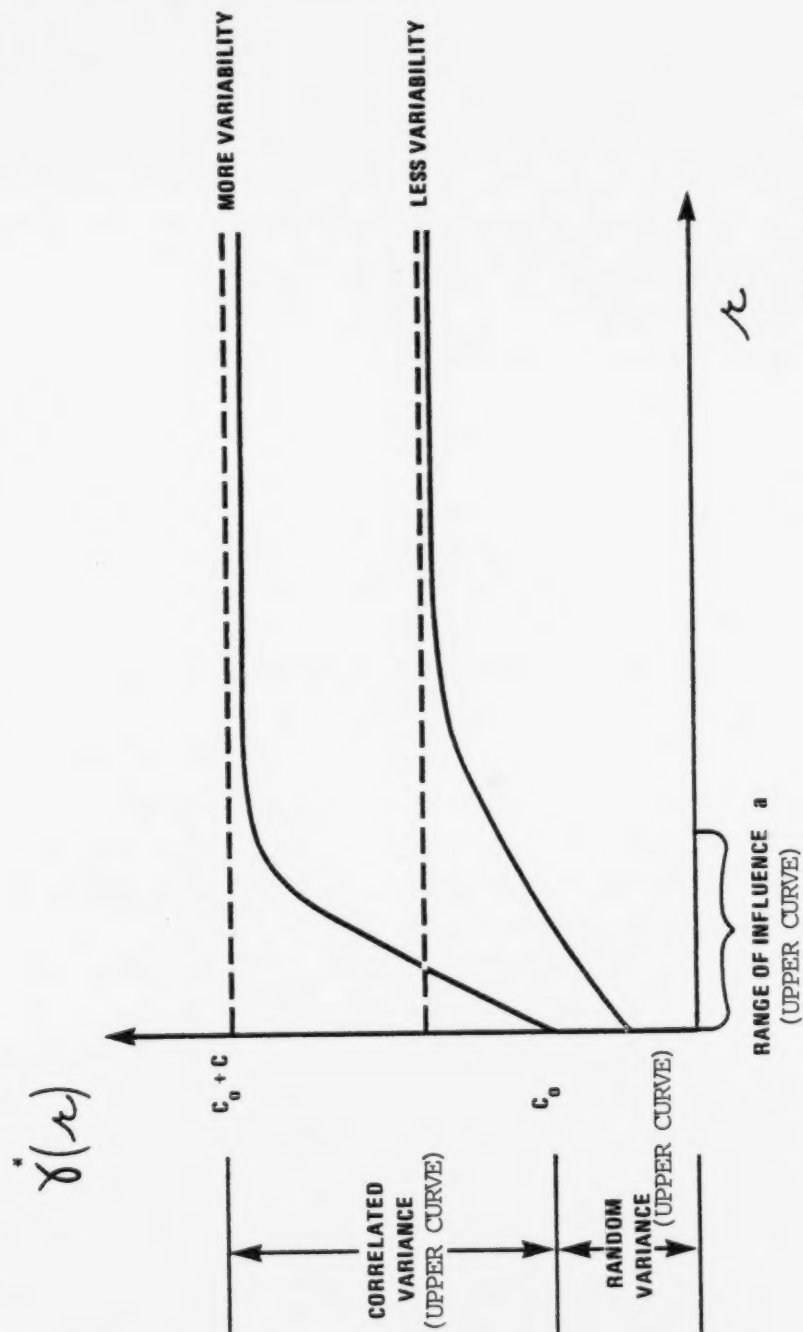


Figure 8-1. Examples of semi-variogram.

22-Hour Increment Study--

Figures 8-2 through 8-7 illustrate the experimental semi-variograms of 30-minute increment data obtained during the 22-hour study for total sulfur, pyritic sulfur, organic sulfur, ash, heating value, and emission rate. For the purpose of a quantitative comparison, the semi-variograms for ROM coal and clean coal are plotted on the same graph using the same scales. However, it must be remembered that the values are calculated on different weight bases due to material losses during cleaning. The abscissa represents time lag in units of 30-minute increments. The ordinate represents the semi-variogram values in units of weight percent squared for sulfur and ash, $(\text{Btu/lb})^2$ for heating value, and $(\text{lb SO}_2/10^6 \text{ Btu})^2$ for emission parameter. Table 8-1 includes basic measurements of mean and variance and geostatistical estimates obtained from semi-variograms. The nugget constant C_0 and sill value $C_0 + C$ are included in Table 8-1. They provide an assessment of random and correlated components of variance.

It can be seen from Figure 8-2 that the semi-variograms of total sulfur for ROM coal and clean coal exhibit markedly different features. Both curves start almost from the same point at lag 1. The nugget constants are determined by linear extrapolation from data at lag 1 and lag 2. These values are found to be 0.005 and 0.006 for clean coal and raw coal, respectively. The curve for clean coal is relatively flat and reaches its sill value of 0.008 asymptotically, while the corresponding curve for ROM coal shows rapid increase at first followed by rapid decrease. There is some ambiguity as to what the sill value should be in this case. Practical experience in mining geostatistics has shown that the sill value is less than or equal to the total variance and passes through the flat part of the curve. Accordingly, a sill value of 0.028 is chosen from Figure 8-2 for ROM coal. A comparison of these two curves strongly suggests that the variability of the total sulfur is reduced by physical coal cleaning. A third curve (heavy solid line) illustrates the corresponding semi-variogram using the R & F in-house data for clean coal. The differences between two semi-variograms for clean coal are minimal.

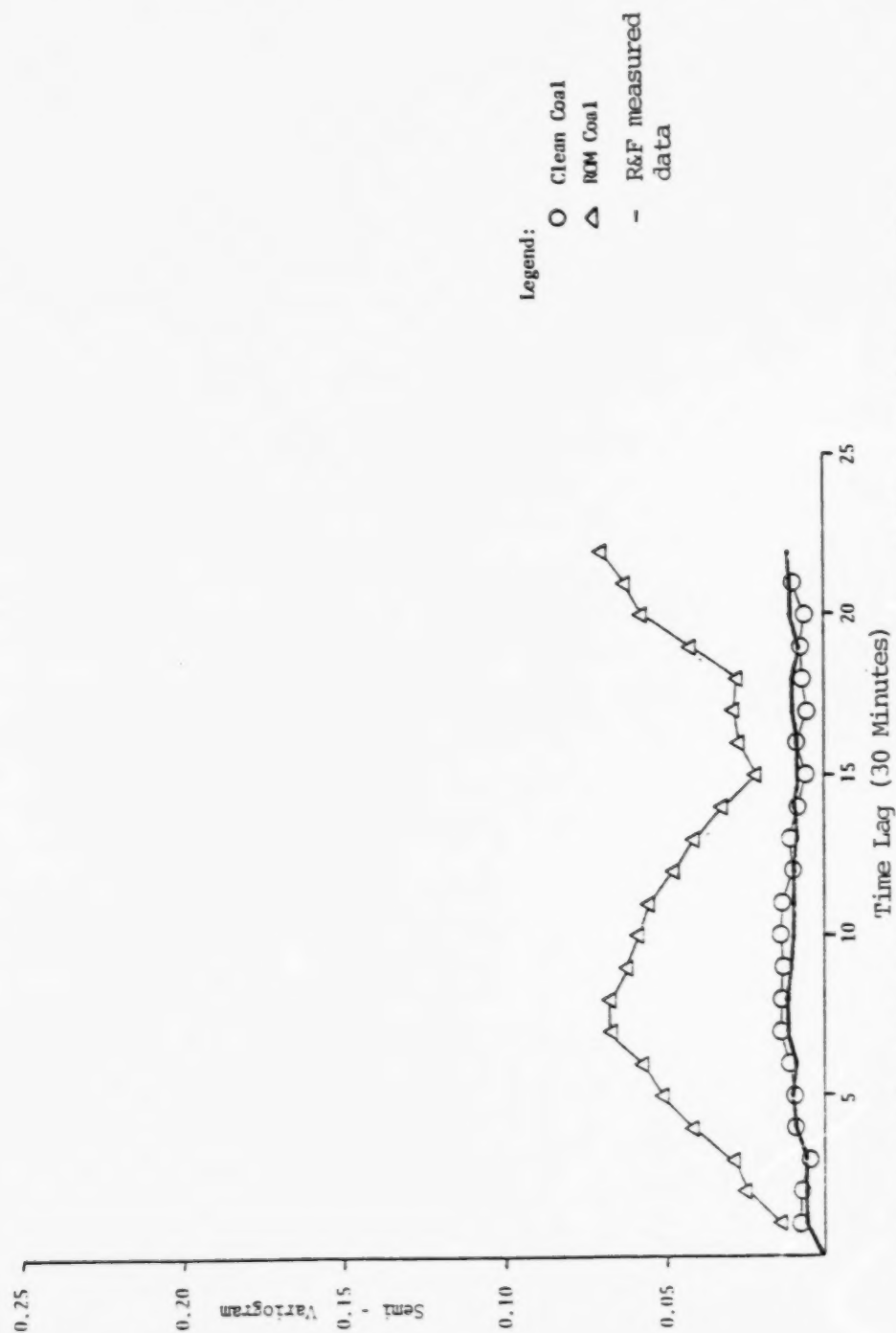


Figure 8-2. R&F Coal Company - semi-variogram of 30-minute increment data (22-hour study) for total sulfur.

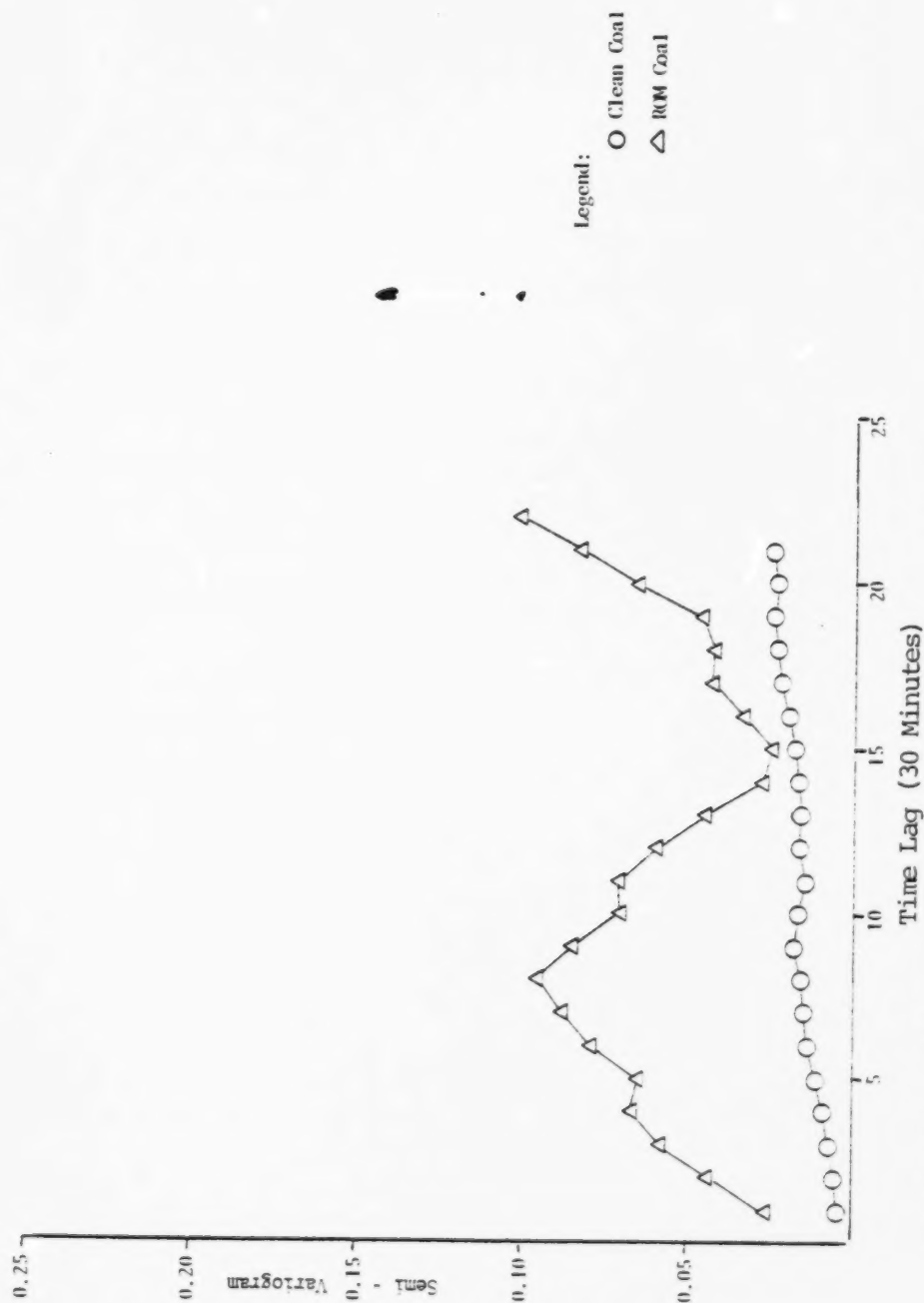


Figure 8-3. R&F Coal Company - semi-variogram of 30-minute increment data (22-hour study) for pyritic sulfur.

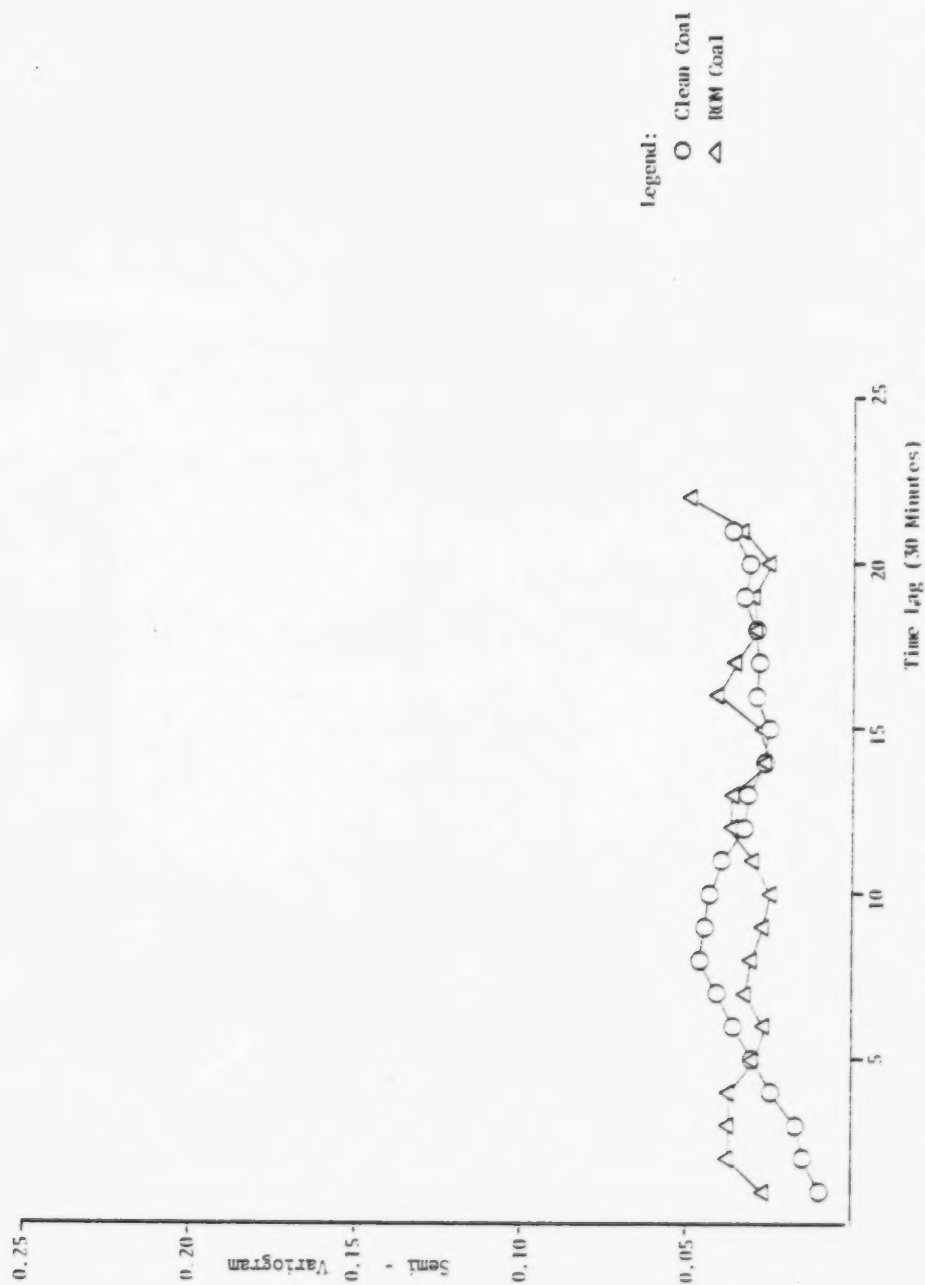


Figure 8-4. R&F Coal Company - semi-variogram of 30-minute increment data (22-hour study) for organic sulfur.

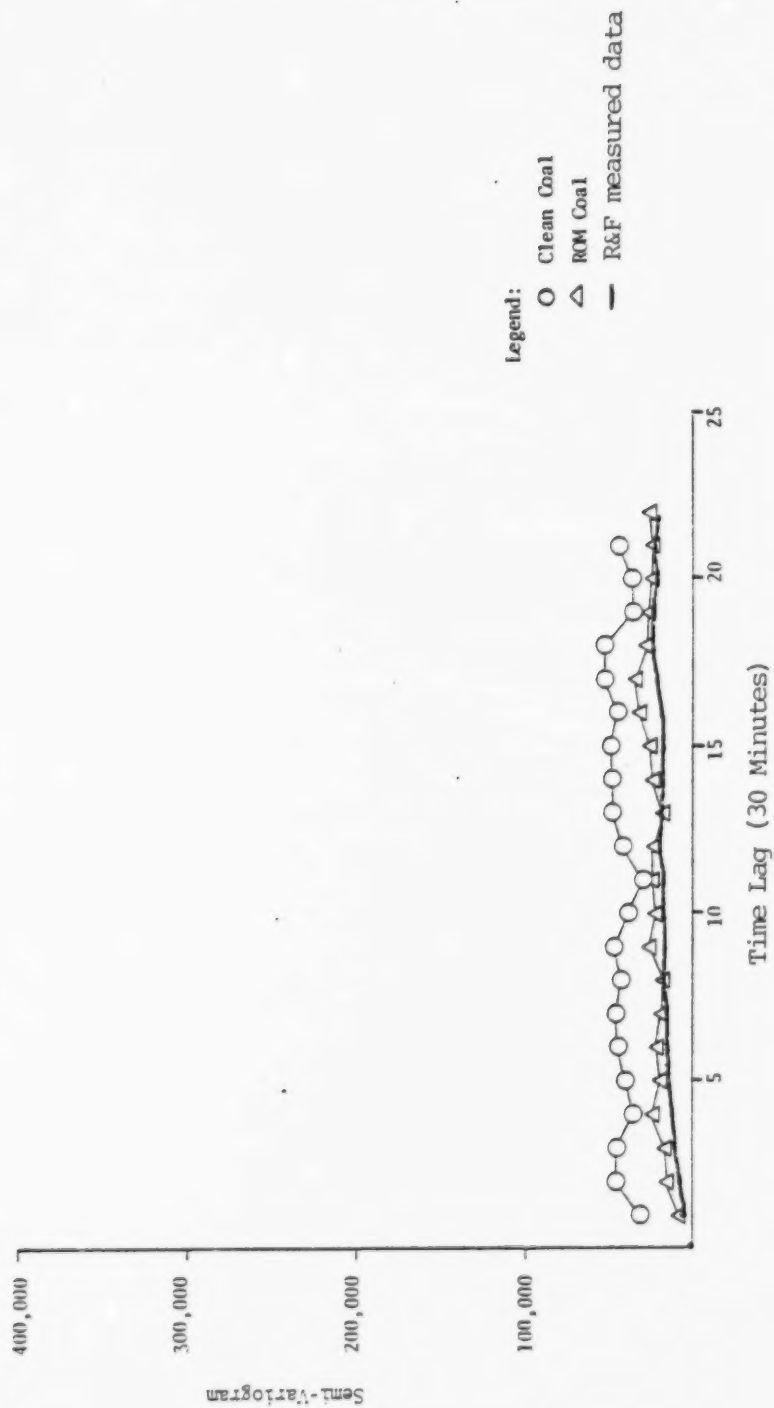


Figure 8-5. R&F Coal Company - semi-variogram of 30-minute increment data (22-hour study) for heating value.

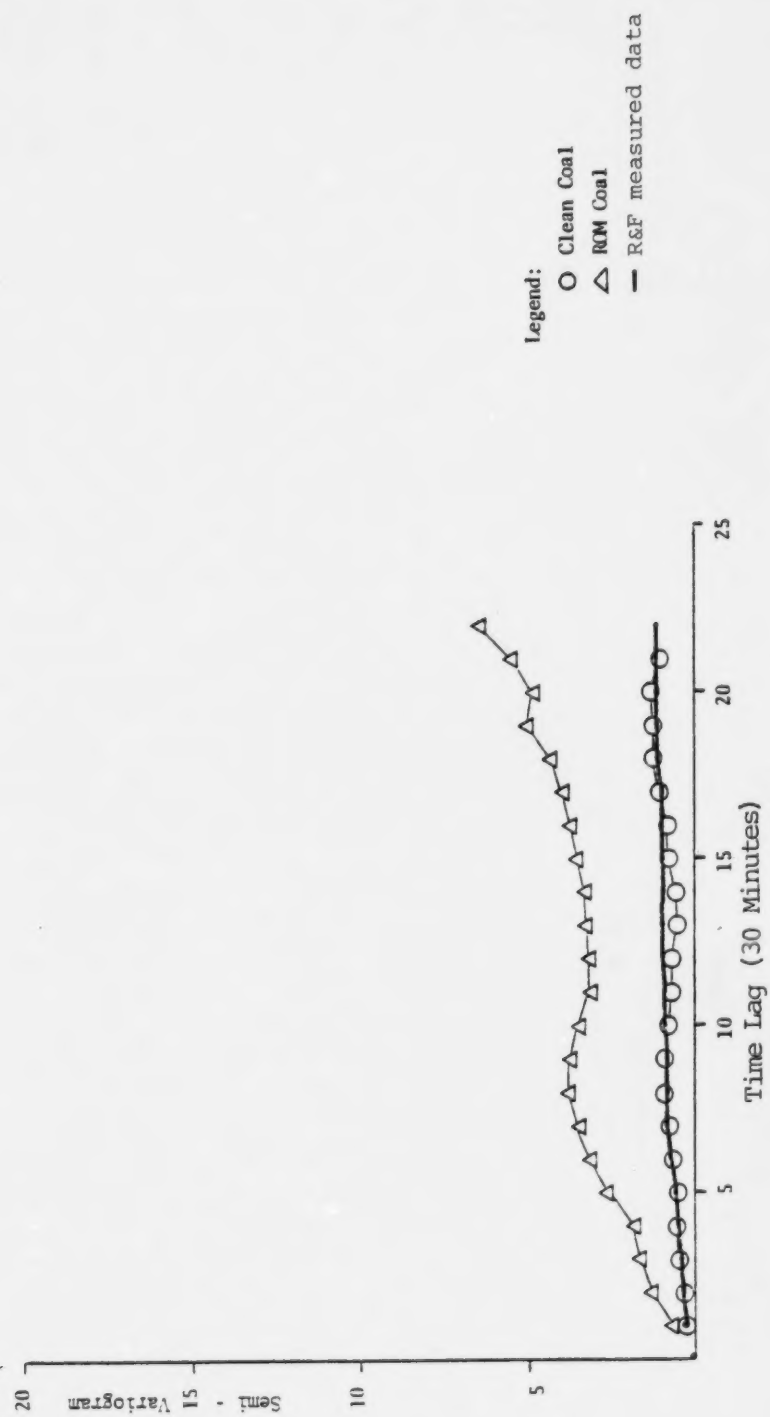


Figure 8-6. R&F Coal Company - semi-variogram of 30-minute increment data (22-hour study) for ash content.

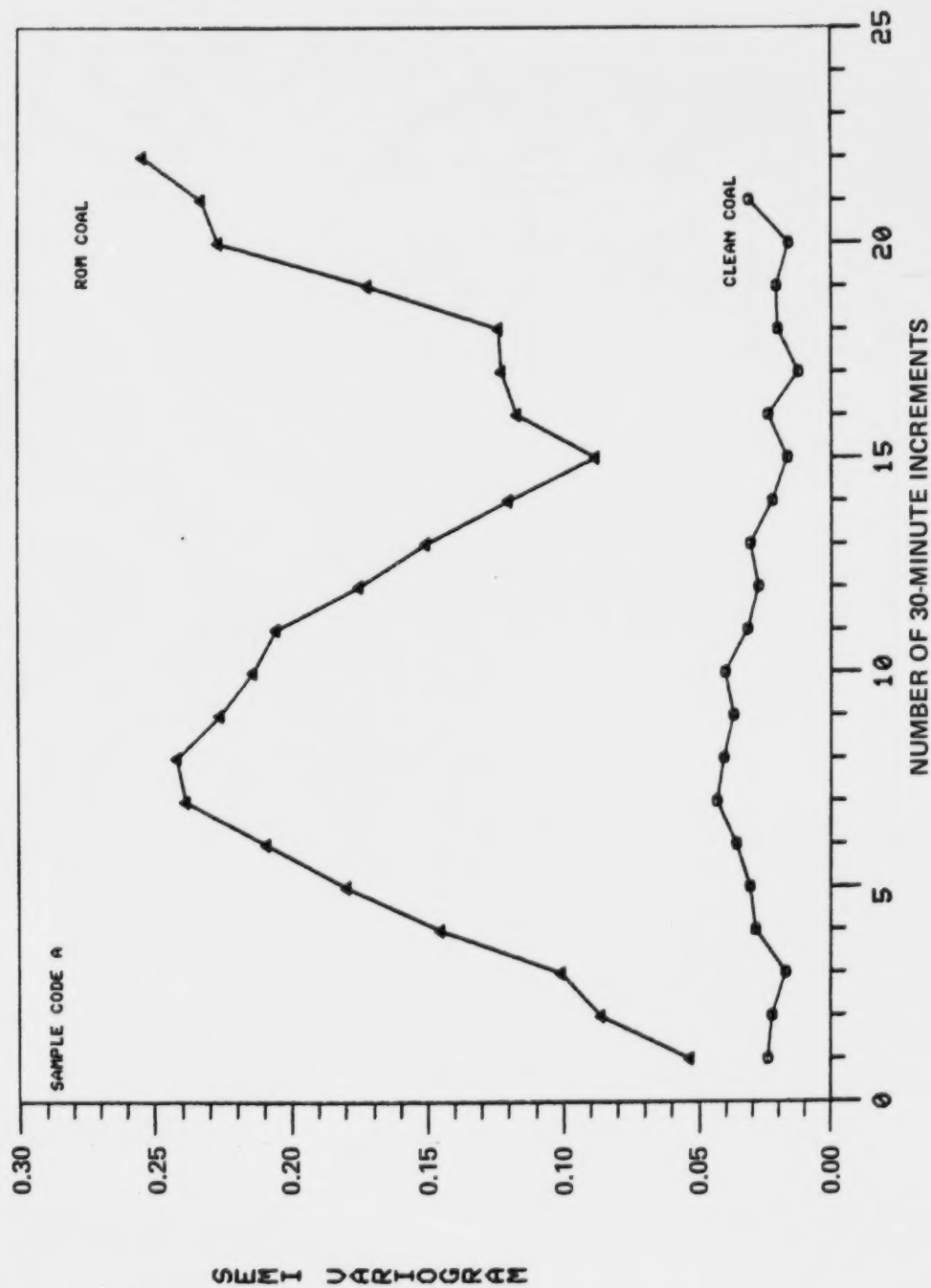


Figure 8-7. R&F Coal Company - semi-variogram of 30-minute increment data (22 hours) for sulfur dioxide emission rate.

TABLE 8-1. R&F COAL COMPANY - RANDOM AND CORRELATED VARIANCES FOR 22-HOUR
STUDY (A) OF SAMPLES COLLECTED AT 30-MINUTE INCREMENTS

ROM COAL SUMMARY						
	BASIC STATISTICS		GEOSTATISTICS			
	MEAN*	VARIANCE†	NUGGET CONSTANT†	SILL VALUE†	CORRELATED VARIANCE†	
	x	s ²	C ₀	C ₀ +C	C	
Total Sulfur	2.822	0.045	0.006	0.028	0.022	
Pyritic Sulfur	1.578	0.063	0.011	0.045	0.034	
Organic Sulfur	1.244	0.035	0.016	0.027	0.011	
Heating Value	11,117	23,166	6,183	18,577	12,394	
Ash Content	20.59	4.83	0.15	3.00	2.85	
Emission Rate	5.073	0.163	0.021	0.121	0.100	
CLEAN COAL SUMMARY						
Total Sulfur	2.390	0.011	0.005	0.008	0.003	
Pyritic Sulfur	1.239	0.015	0.003	0.015	0.012	
Organic Sulfur	1.151	0.029	0.005	0.026	0.021	
Heating Value	12,156	47,293	12,419	40,000	27,581	
Ash Content	14.08	0.850	0.068	0.800	0.732	
Emission Rate	3.928	0.029	0.021	0.029	0.008	

* Units are weight % for sulfur and ash, Btu/lb for heating value, and lb SO₂/10⁶ Btu for emission parameter.

† Units are weight %² for sulfur and ash, (Btu/lb)² for heating value, and (lb SO₂/10⁶ Btu)² for emission parameter.

Figure 8-3 shows the corresponding semi-variograms for pyritic sulfur. The nugget constant and sill value are determined in the same manner described above. There is marked similarity between Figure 8-2 (total sulfur) and Figure 8-3 (pyritic sulfur). A comparison of the raw and clean coal suggests that the variability as well as the mean concentration of pyritic sulfur is also reduced by physical coal cleaning.

Figure 8-4 shows that, unlike the cases of total sulfur and pyritic sulfur, the semi-variograms for organic sulfur are not markedly different for raw and clean coal. These semi-variogram values are similar for both raw and clean coal at different lag times. The results suggest that the variability of organic sulfur is insensitive to the process of coal cleaning. Comparison of Figures 8-2, 8-3, and 8-4 clearly illustrates that coal preparation (due to blending, cleaning, and homogenizing) reduces the variability of pyritic sulfur and total sulfur. This follows from the fact that physical coal cleaning removes large discrete particles of pyrite, which is a major contributor to the randomness of sulfur in coal.

Figure 8-5 shows the semi-variograms of heating value (Btu/lb) for raw coal and clean coal. Intuitively, one may expect that since coal cleaning removes pyritic sulfur and ash, the variability in heating value for clean coal would be reduced. Analysis of Versar raw and clean coal Btu data, however, does not indicate that variability is reduced. Plotting R & F's data for clean coal and comparing it to Versar's raw coal data indicates that semi-variogram values are slightly lower for clean coal. The discrepancy between the Versar and R & F clean coal semi-variogram curves does not appear to be the result of differences in the coal characteristics.

Figure 8-6 shows the semi-variograms for ash. The heavy solid curve indicates excellent agreement between Versar's analysis and R & F's in-house data. Since ash appears as discrete particles like pyrite, removal of the ash by coal cleaning reduces the variability of ash.

Figure 8-7 contains semi-variograms for emission parameter. Comparison with Figures 8-2 for total sulfur and 8-5 for heating value shows that the variation in emission parameter closely follows the variation of total sulfur and is not markedly affected by variations in heating value.

40-Hour Increment Study--

Figures 8-8 through 8-13 illustrate the experimental semi-variograms of 30-minute increment data during the 40-hour intensive study for total sulfur, pyritic sulfur, organic sulfur, heating value, ash, and emission rate. Table 8-2 presents the random variance and correlated variance for these data. Figures 8-8, 8-9, and 8-10 confirm earlier observations that the variability in total sulfur and pyritic sulfur is reduced by coal cleaning while the variability in organic sulfur is relatively insensitive to coal cleaning. However, a closer comparison between Figure 8-2 and Figure 8-8, Figure 8-3 and Figure 8-9, Figure 8-4 and Figure 8-10 shows that the variability in the 40-hour study is greater than that for the 22-hour study.

Figure 8-11 illustrates the semi-variogram of heating value for clean coal and raw coal. The semi-variogram values for clean coal are consistently smaller than those for raw coal. This supports other geostatistical analyses and the concept that there is reduction in variability in heating value for clean coal because of the reduction in ash and pyritic sulfur content.

8-Hour Interval Study--

Figures 8-14 through 8-19 illustrate the semi-variograms of 8-hour interval data during the 7-week study. The semi-variograms are truncated at time lag 16 because of the small number of data pairs. Semi-variogram values beyond this point were not considered to be reliable. The attenuated variability for clean coal in total sulfur, pyritic sulfur, and ash is again quantified in Figures 8-14, Figures 8-15, and Figure 8-16. The summary of random variance and correlated variance is presented in Table 8-3.

R & F Measured Data--

Figures 8-20 through 8-23 illustrate the experimental semi-variograms for clean coal using data which resulted from R & F's analysis of measurements at 30-minute increments over the 7 week period. These curves show that sill values were reached for each parameter between 6 and 8 hours. Actual sill values determined from these semi-variograms are presented in Table 8-4. The similarity between the semi-variogram for ash and the

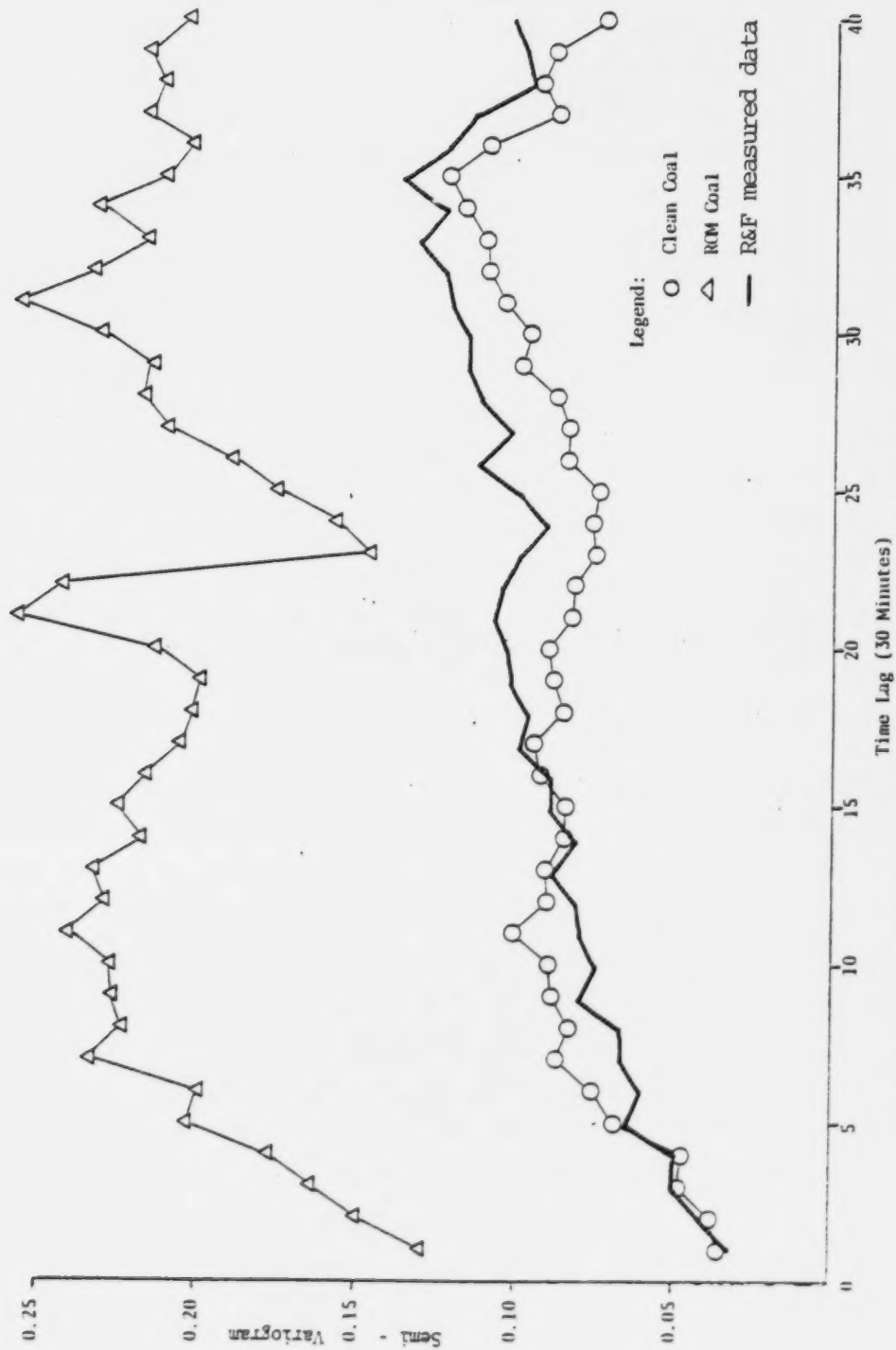


Figure 8-8. R&F Coal Company - semi-variogram of 30-minute increment data (40-hour study) for total sulfur.

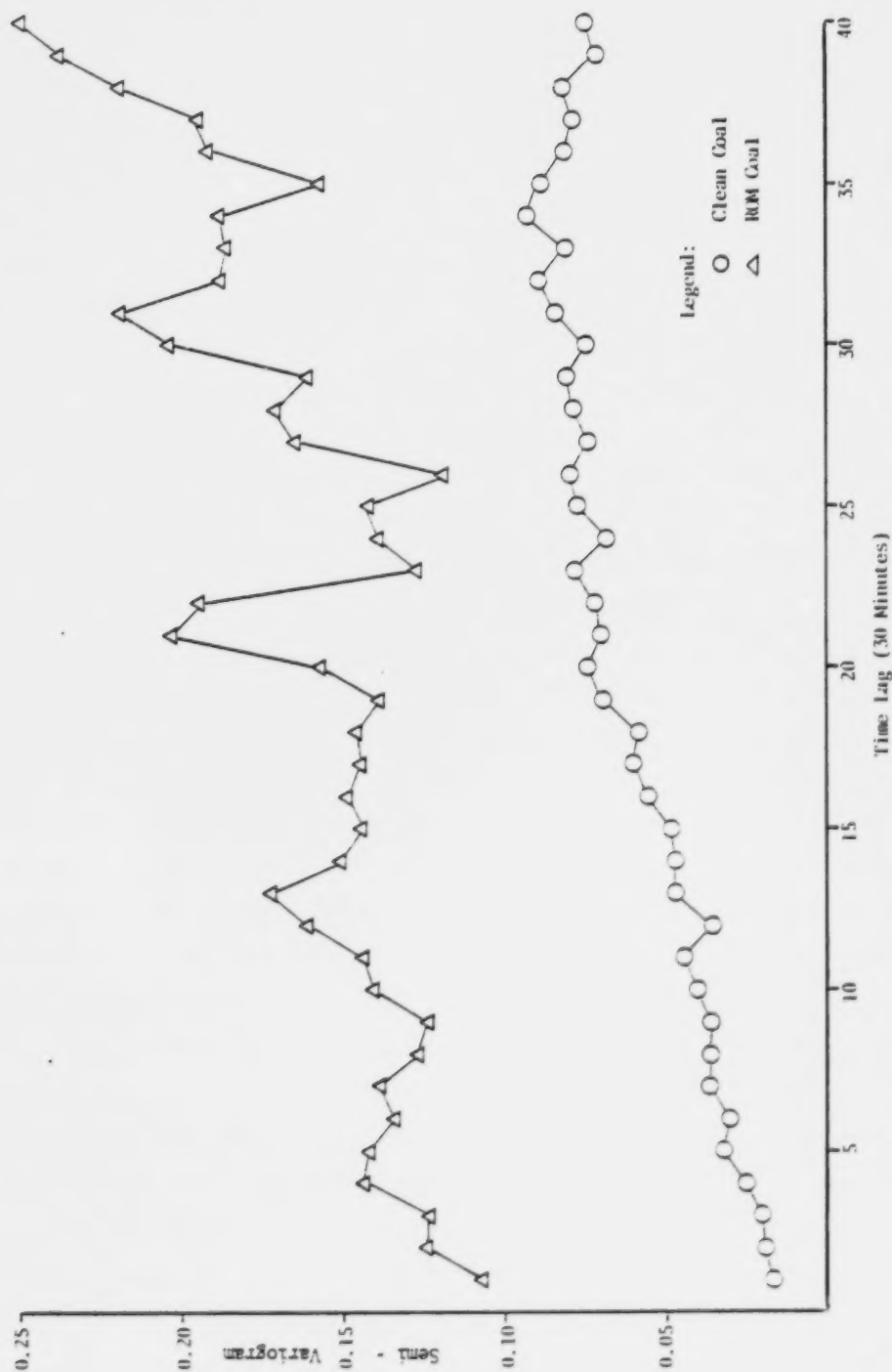


Figure 8-9. R&F Coal Company - semi-variogram of 30-minute increment data (40-hour study) for pyritic sulfur.

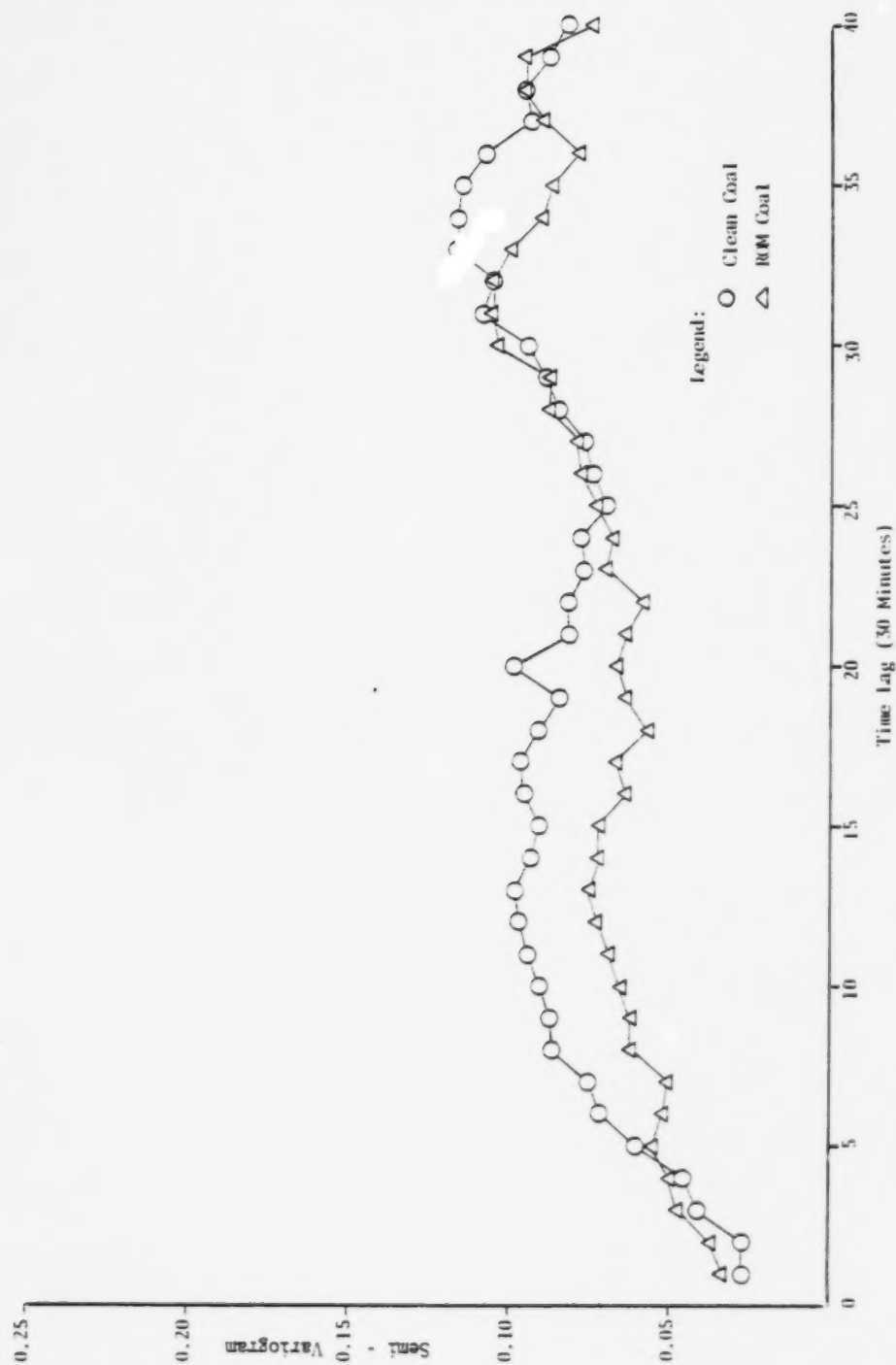


Figure 8-10. R&F Coal Company - semi-variogram of 30-minute increment data (40-hour study) for organic sulfur.

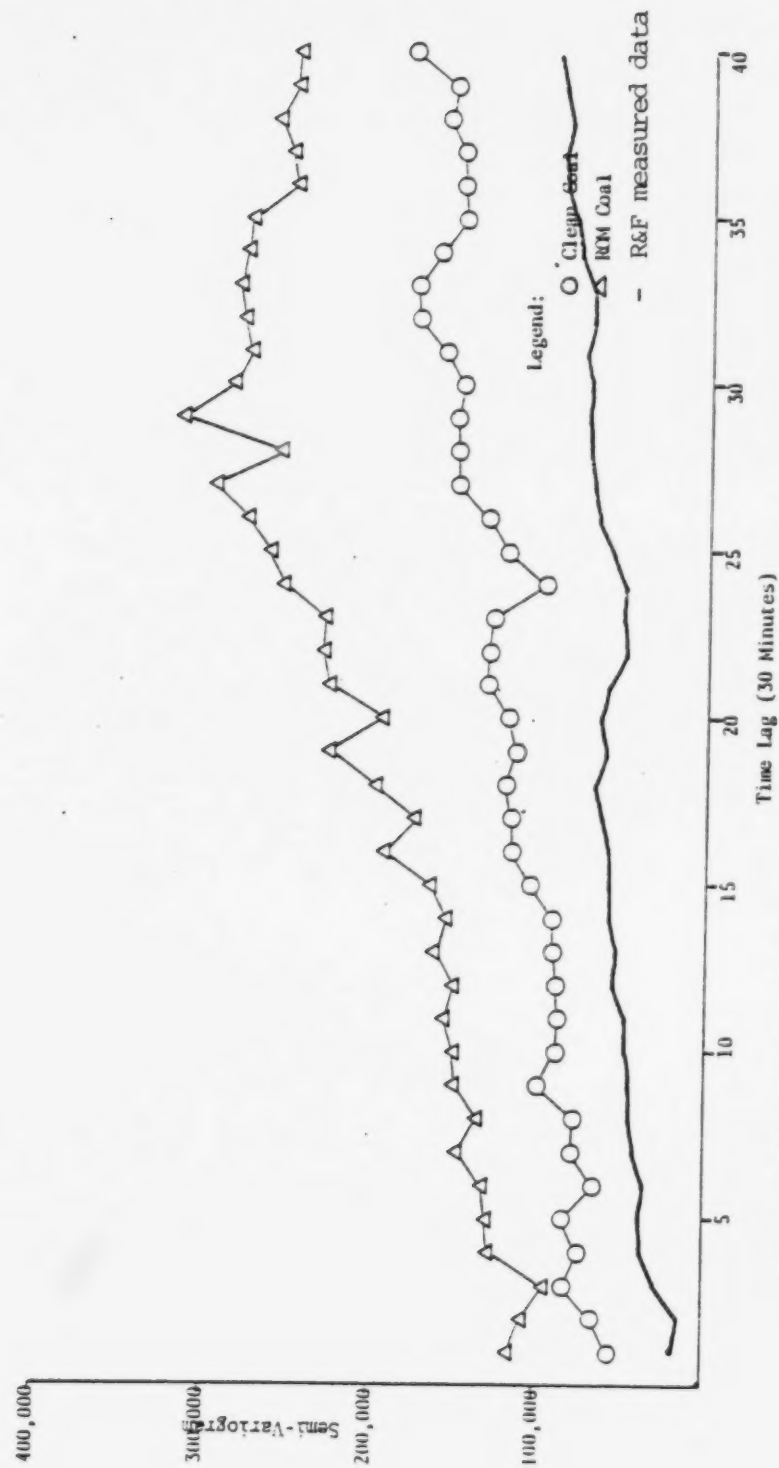


Figure 8-11. R&F Coal Company - semi-variogram of 30-minute increment data (40-hour study) for heating value.

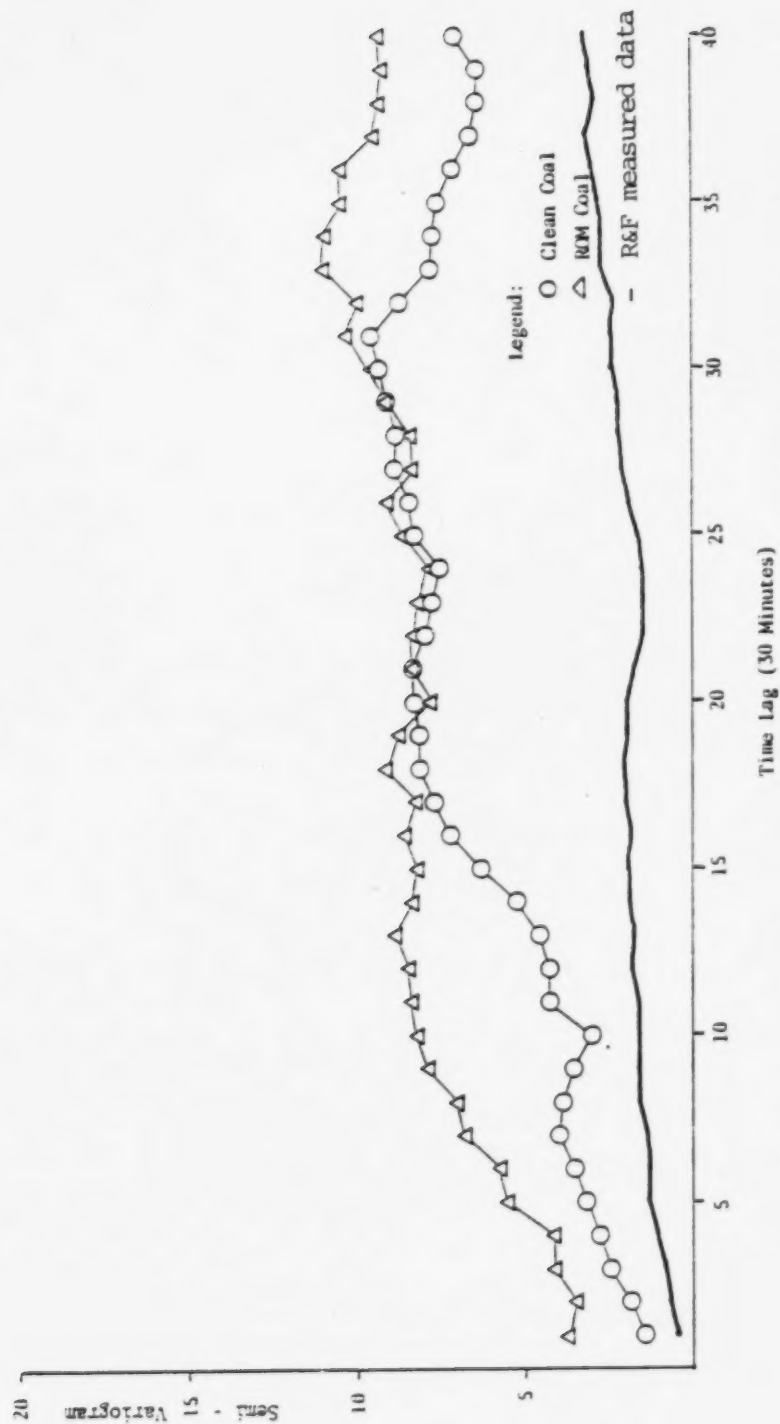


Figure 8-12. R&F Coal Company - semi-variogram of 30-minute increment data (40-hour study) for ash content.

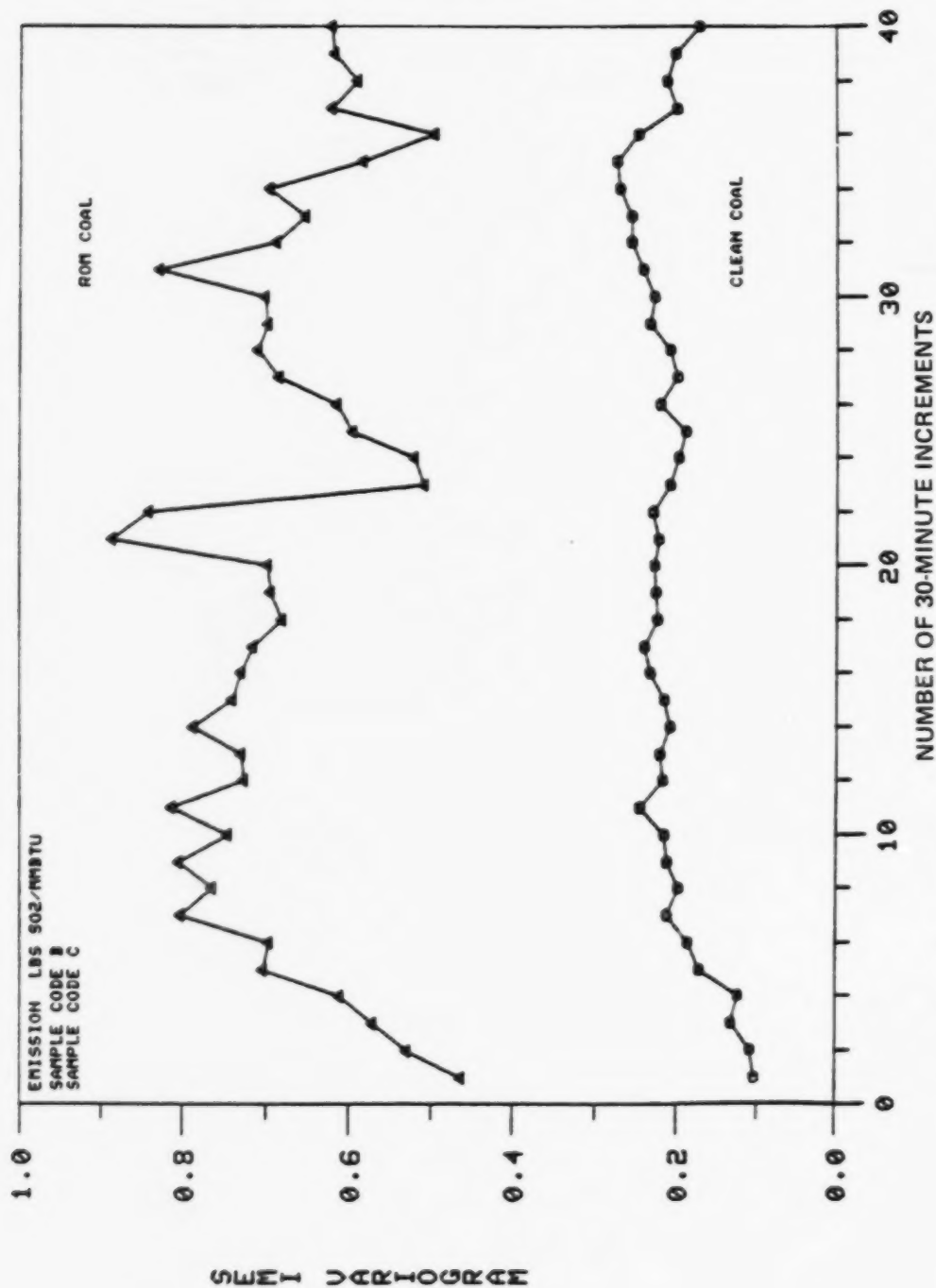


Figure 8-13. Semi-variogram of 30-minute increment data (40-hour study, B&C) for sulfur dioxide emission rate.

TABLE 8-2. R&F COAL COMPANY - RANDOM AND CORRELATED VARIANCES FOR 40-HOUR STUDY (B&C) OF SAMPLES COLLECTED AT 30-MINUTE INCREMENTS

ROM COAL SUMMARY					
BASIC STATISTICS		GEOSTATISTICS			
MEAN*	VARIANCE†	NUGGET CONSTANT†	SILL VALUE†	CORRELATED VARIANCE†	
x	S ²	C _O	C _O +C	C	
Total Sulfur	3.227	0.109	0.200	0.091	
Pyritic Sulfur	1.999	0.094	0.144	0.050	
Organic Sulfur	1.228	0.028	0.075	0.047	
Heating Value	11,296	114,944	251,000	136,056	
Ash Content	20.146	1.86	3.84	1.98	
Emission Rate	5.713	0.400	0.640	0.240	
CLEAN COAL SUMMARY					
Total Sulfur	2.729	0.036	0.078	0.042	
Pyritic Sulfur	1.339	0.015	0.060	0.045	
Organic Sulfur	1.390	0.028	0.078	0.050	
Heating Value	12,395	42,885	151,000	108,115	
Ash Content	12.190	1.36	7.60	6.24	
Emission Rate	4.399	0.100	0.190	0.090	

* Units are weight % for sulfur and ash, Btu/lb for heating value, and lb SO₂/10⁶ Btu for emission parameter.

† Units are weight %² for sulfur and ash, (Btu/lb)² for heating value, and (lb SO₂/10⁶ Btu)² for emission parameter.

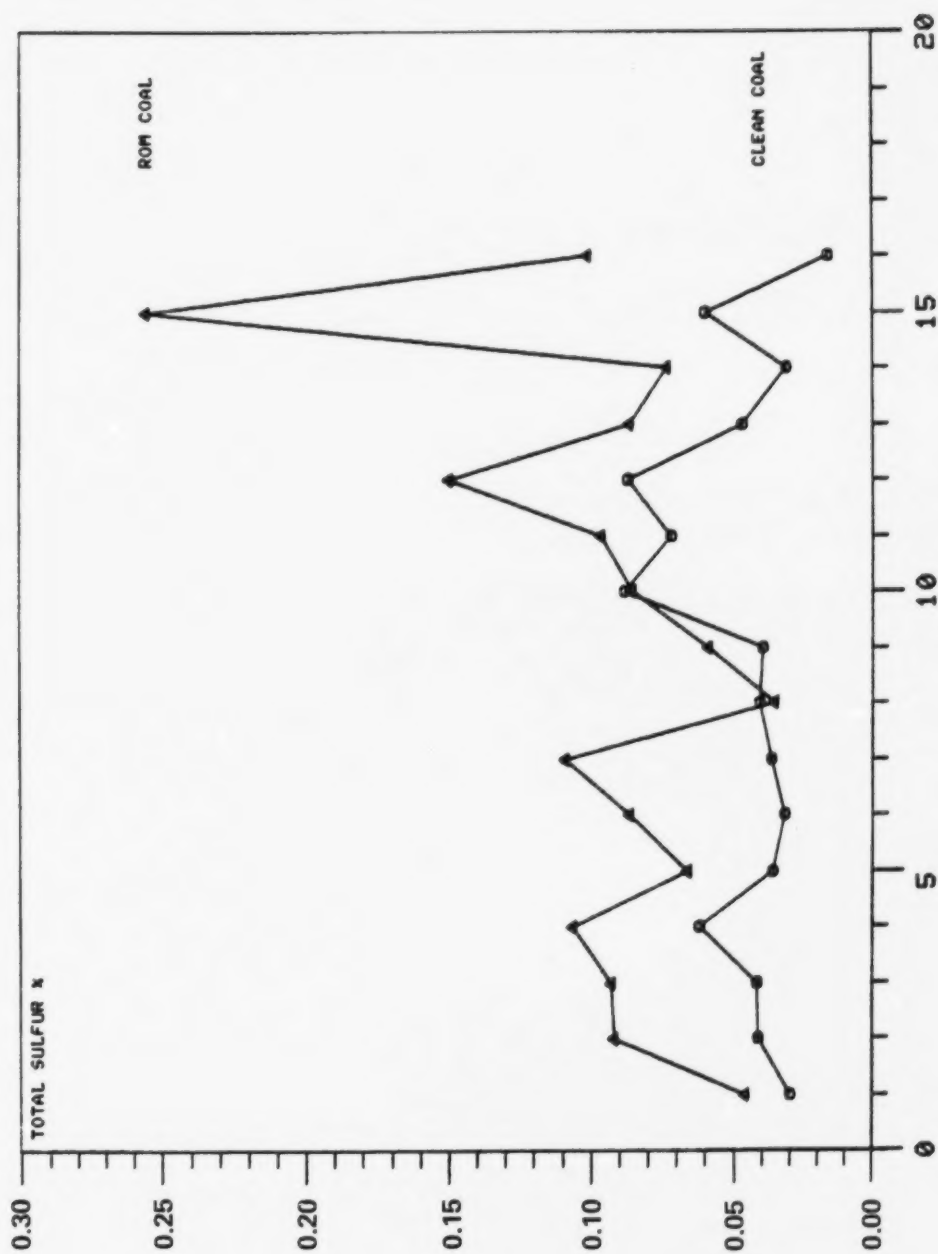


Figure 8-14. R&F Coal Company - semi-variogram of 8-hour interval data for total sulfur.

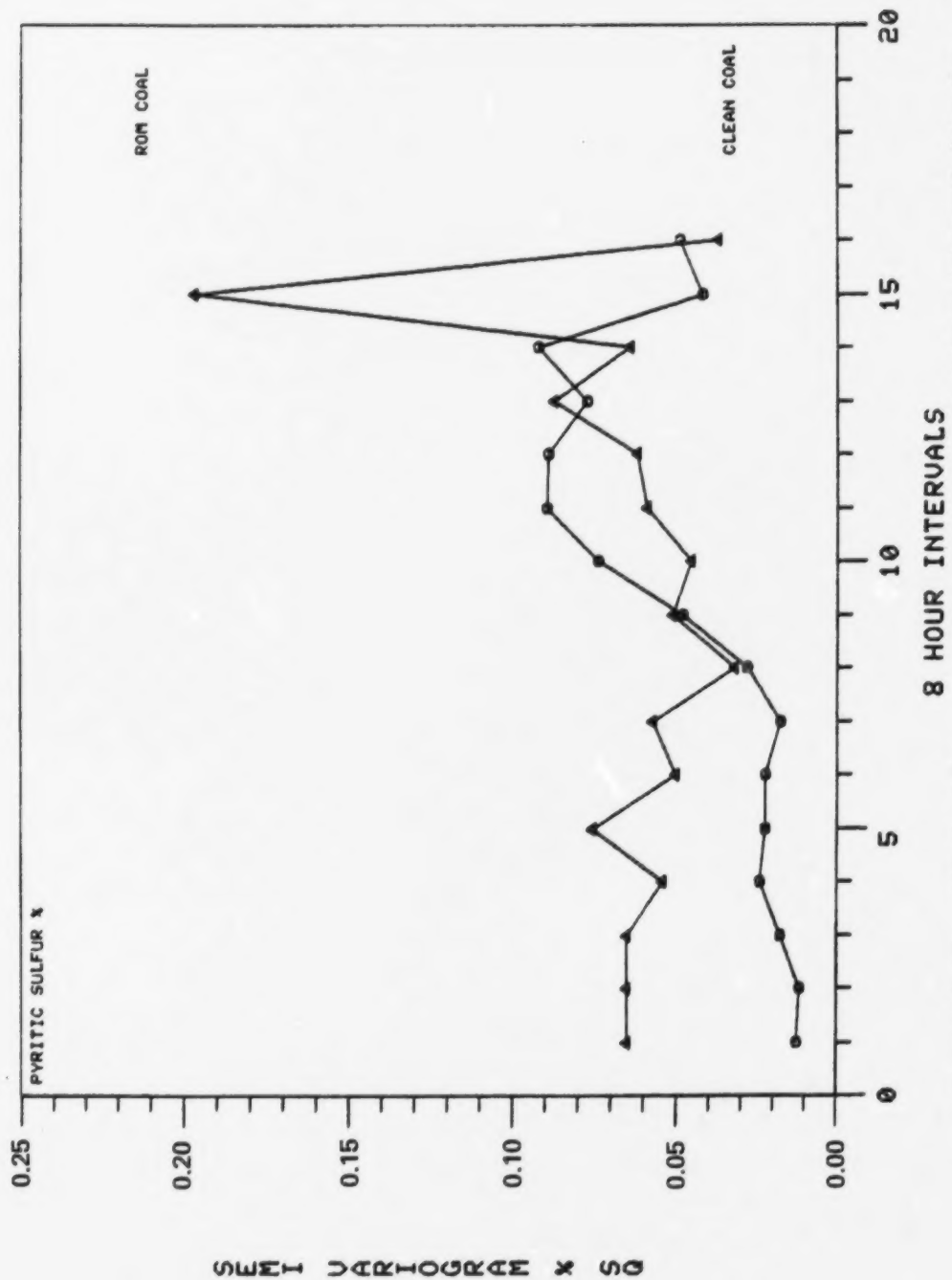


Figure 8-15. R&F Coal Company - semi-variogram of 8-hour interval data for pyritic sulfur.

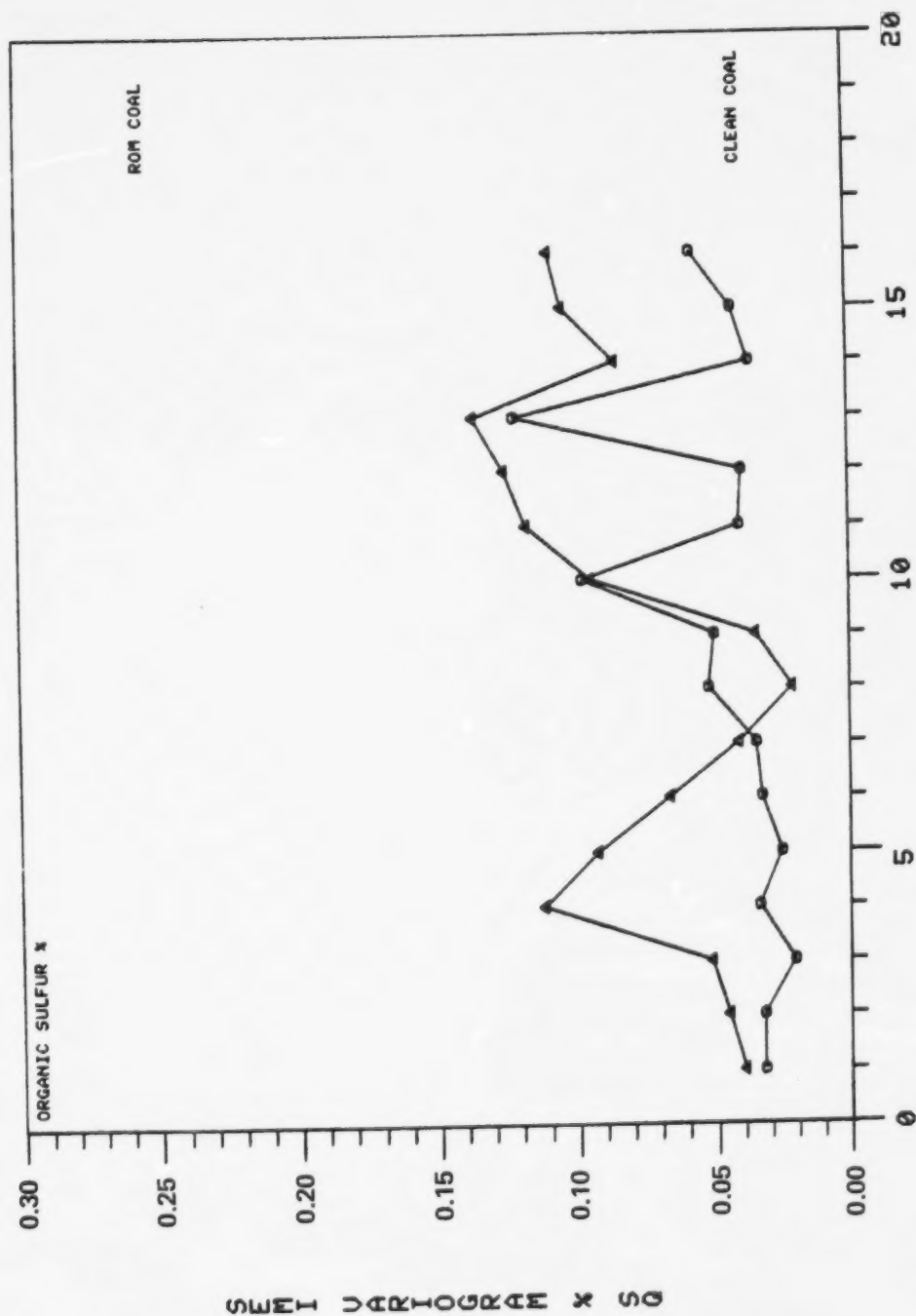


Figure 8-16. R&F Coal Company - semi-variogram of 8-hour interval data for organic sulfur.

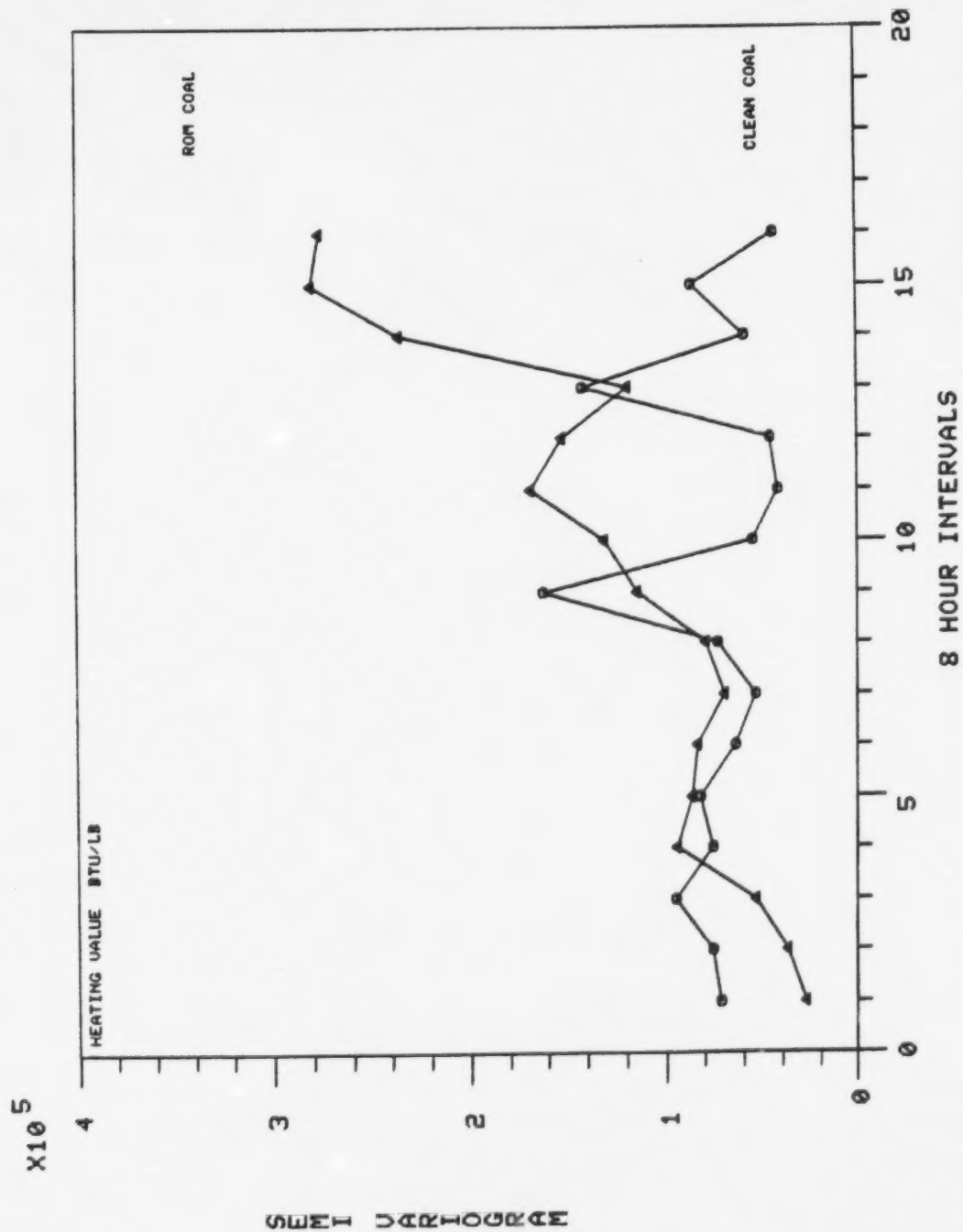


Figure 8-17. R&F Coal Company - semi-variogram of 8-hour interval data for heating value.

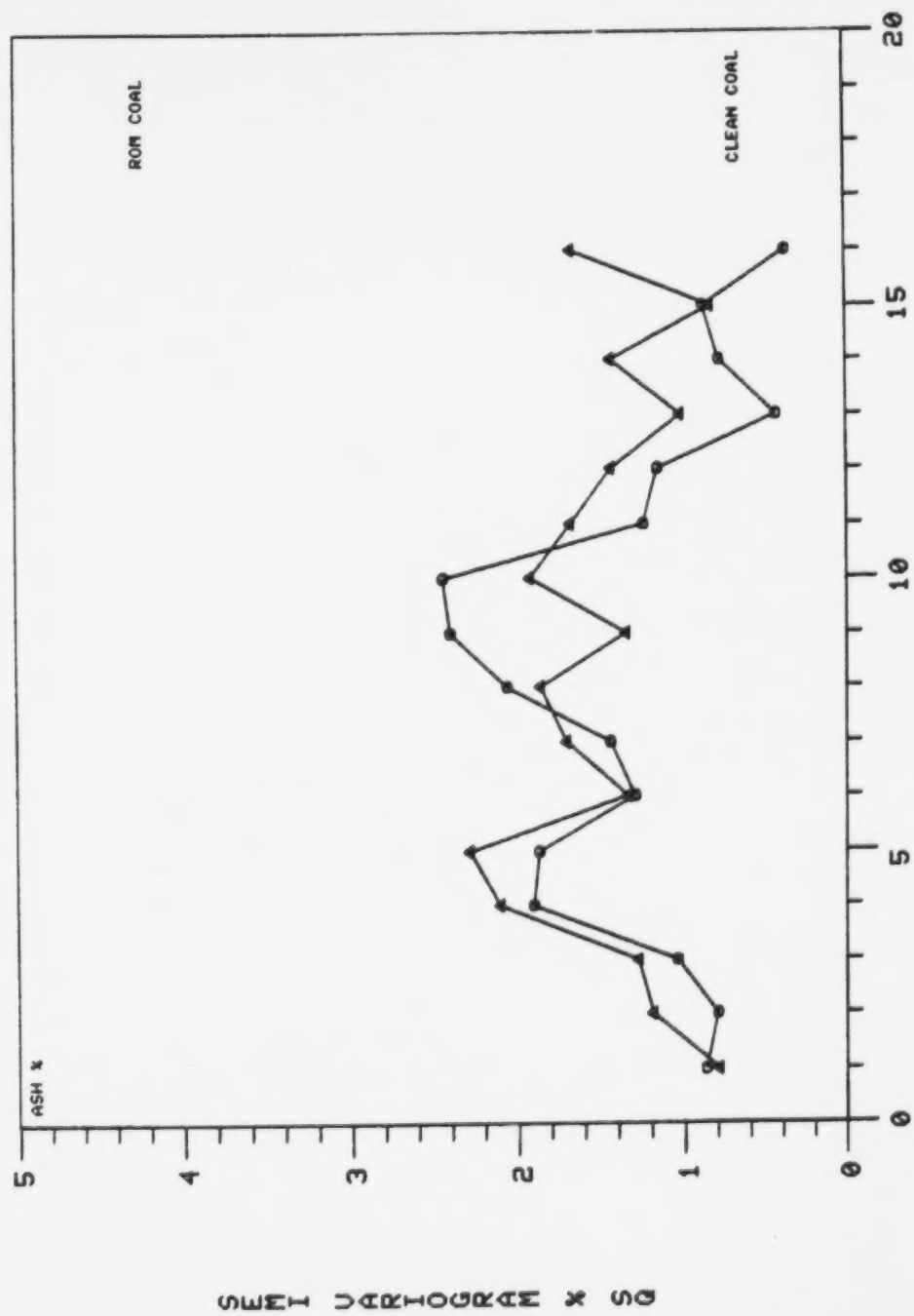


Figure 8-18. R&F Coal Company - semi-variogram of 8-hour interval data for ash content.

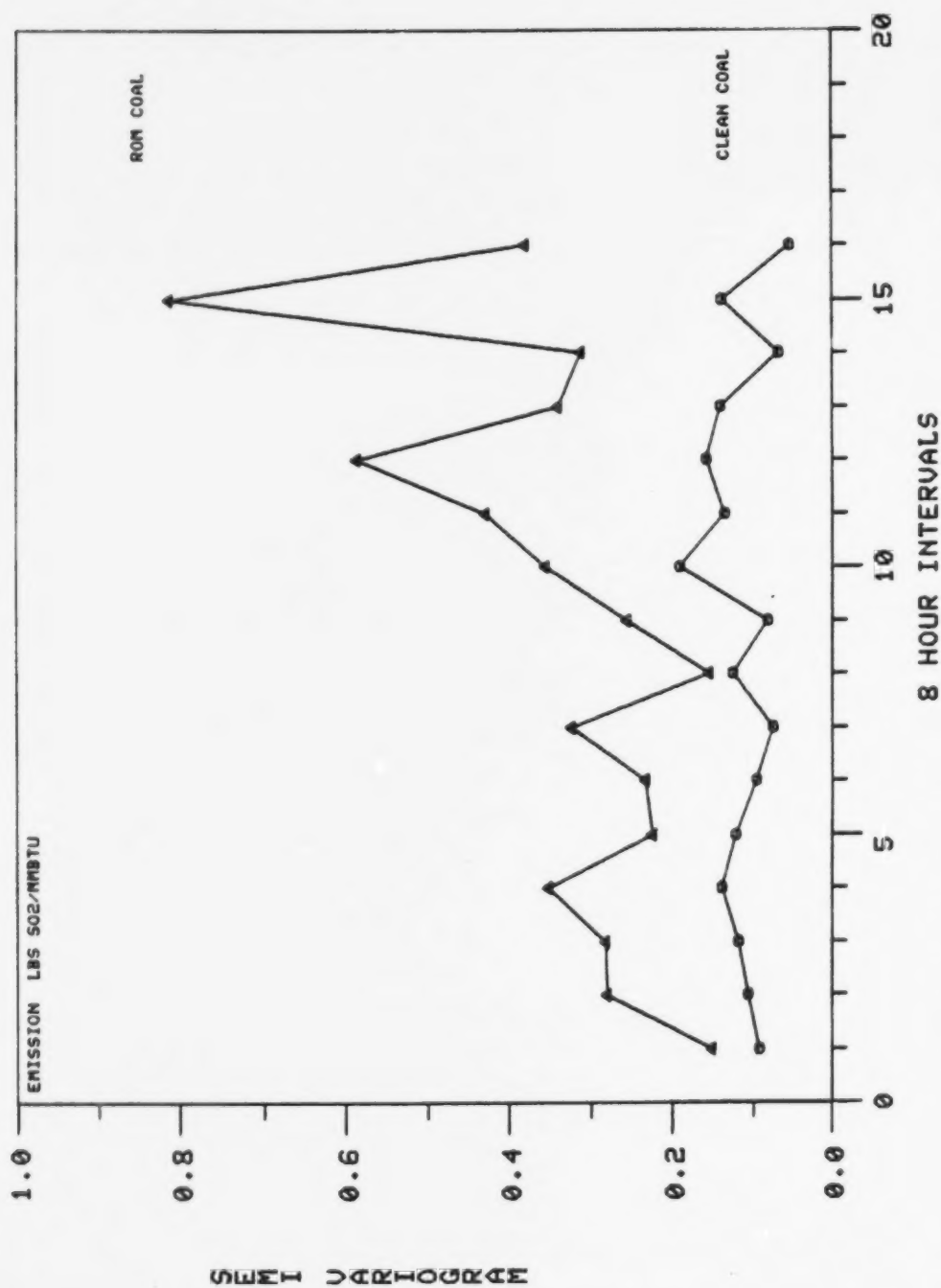


Figure 8-19. R&F Coal Company - semi-variogram of 8-hour interval data for sulfur dioxide emission rate.

TABLE 8-3. R&F COAL COMPANY - RANDOM AND CORRELATED VARIANCES
FOR 8-HOUR COMPOSITE DATA

ROM COAL SUMMARY		GEOSTATISTICS			
BASIC STATISTICS		NUGGET CONSTANT†		SILL VALUE†	
MEAN*	VARIANCE†	C ₀		C ₀ +C	
x	S ²				
Total Sulfur	3.217	0.085	0.060	0.080	0.020
Pyritic Sulfur	1.860	0.106	0.065	0.070	0.005
Organic Sulfur	1.357	0.097	0.035	0.060	0.025
Heating Value	11189.	91405.	20000.	---	---
Ash Content	22.497	1.914	0.40	1.40	1.00
Emission Rate	6.297	1.376	0.03	0.28	0.25
CLEAN COAL SUMMARY					
Total Sulfur	2.667	0.042	0.016	0.040	0.024
Pyritic Sulfur	1.318	0.031	0.010	0.031	0.021
Organic Sulfur	1.350	0.046	0.033	0.040	0.007
Heating Value	12523.	98531.	65633.	70000.	4367.
Ash Content	13.37	1.23	0.65	1.10	0.45
Emission Rate	4.257	0.110	0.07	0.10	0.03

* Units are weight % for sulfur and ash, Btu/lb for heating value, and lb SO₂/10⁶ Btu for emission parameter.

† Units are weight %² for sulfur and ash, (Btu/lb)² for heating value, and (lb SO₂/10⁶ Btu)² for emission parameter.

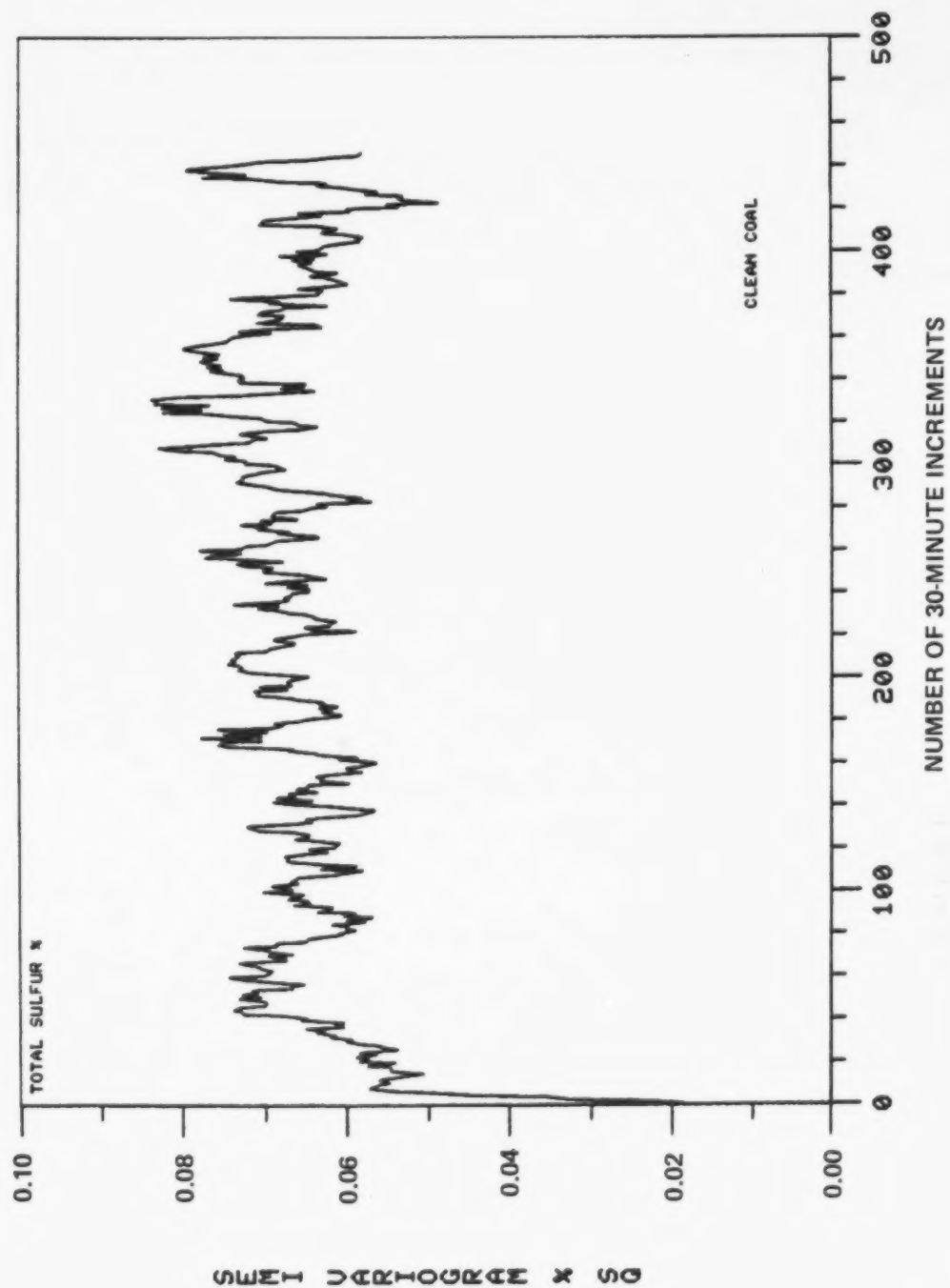


Figure 8-20. R&F Coal Company - semi-variogram of R&F measured data for total sulfur.

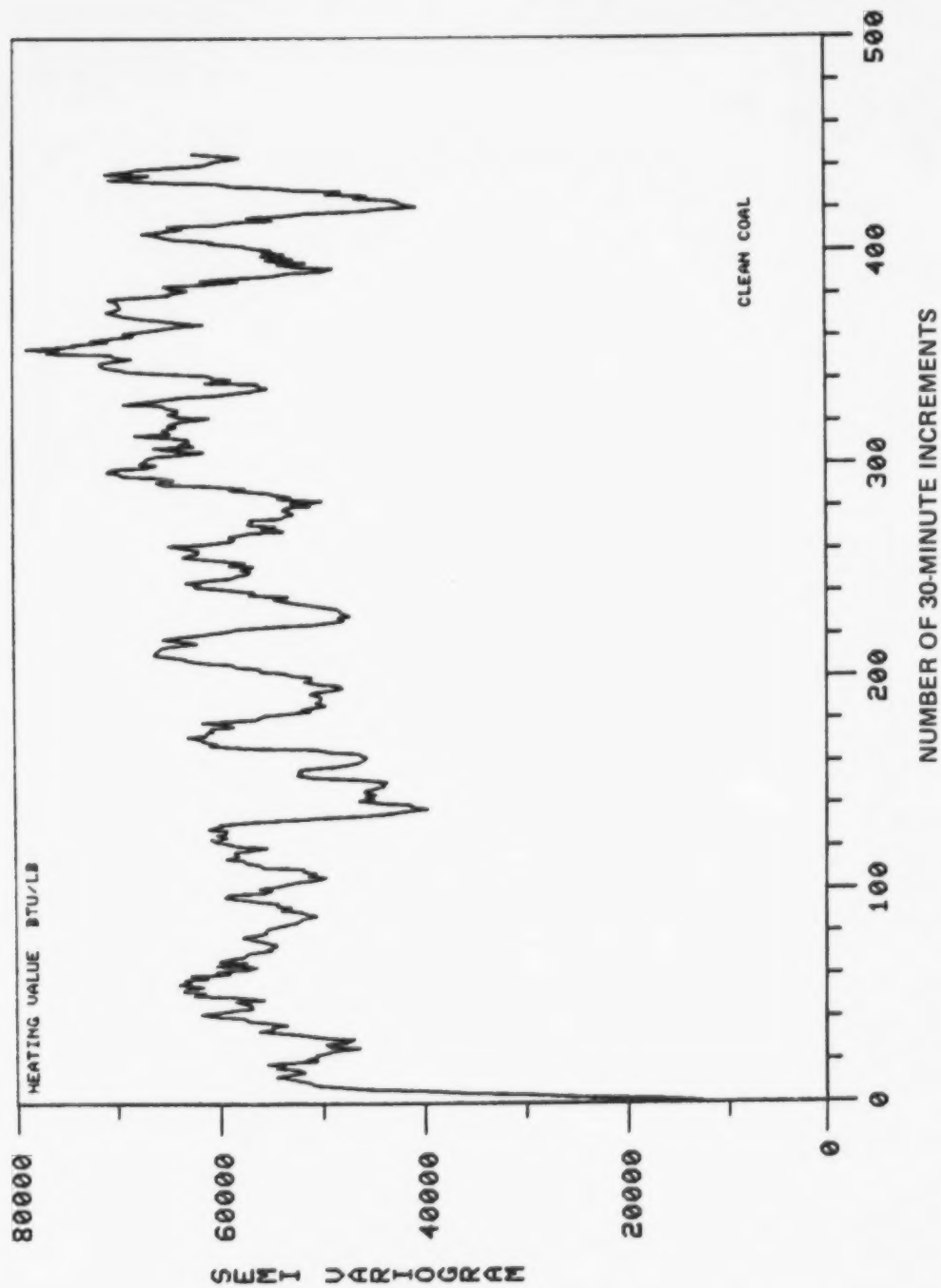


Figure 8-21. R&F Coal Company - semi-variogram of R&F measured data for heating value.

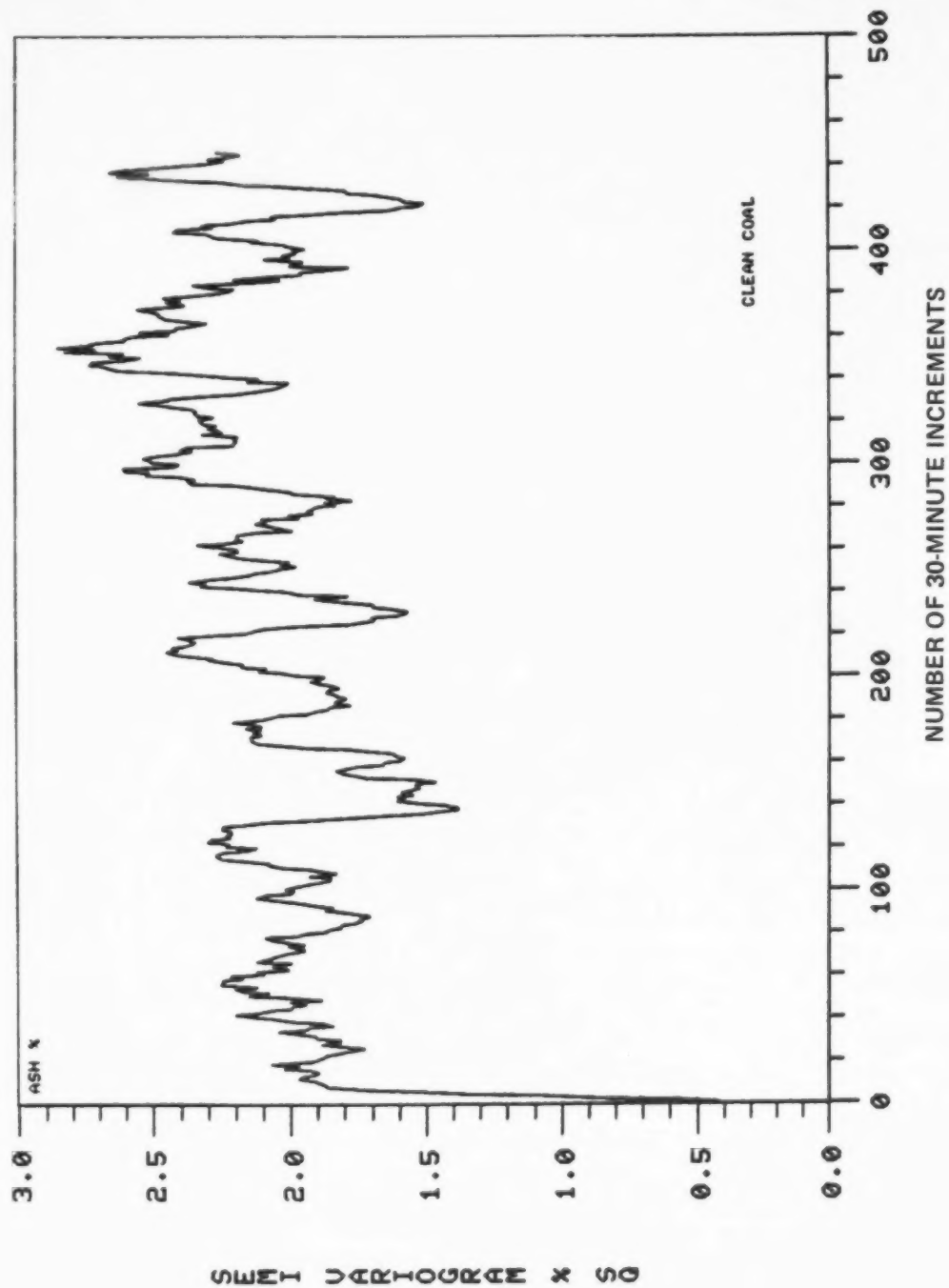


Figure 8-22. R&F Coal Company - semi-variogram of R&F measured data for ash content.

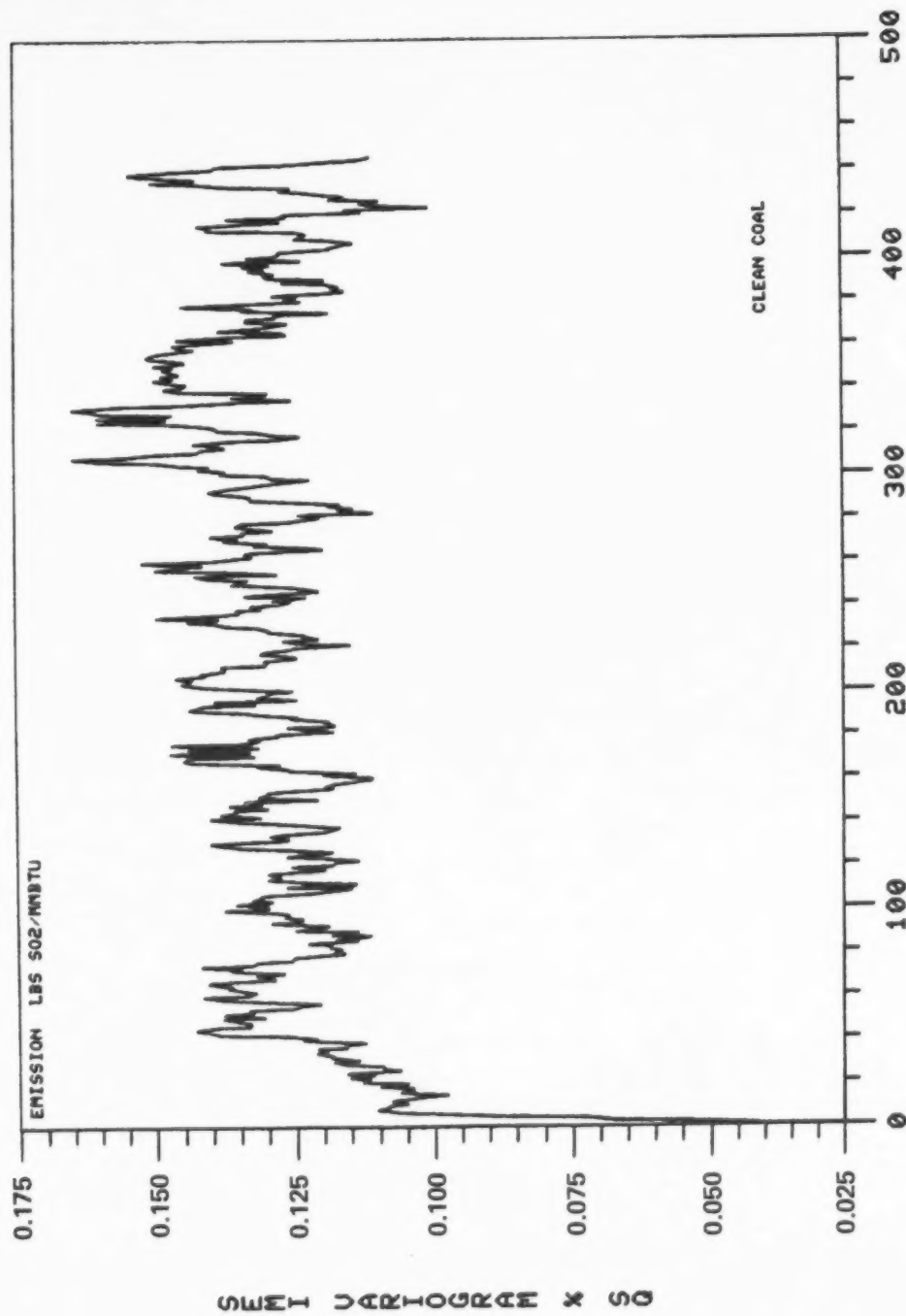


Figure 8-23. R&F Coal Company - semi-variogram of R&F measured data for sulfur dioxide emission rate.

TABLE 8-4. R&F COAL COMPANY MEASURED DATA

CLEAN COAL SUMMARY					
	BASIC STATISTICS		GEOSTATISTICS		
	MEAN*	VARIANCE†	NUGGET CONSTANT†	SILL VALUE†	CORRELATED VARIANCE†
	x	s ²	C ₀	C ₀ +C	C
Total Sulfur	2.648	0.063	0.019	0.060	0.041
Heating Value	12,642	58,722	12,000	50,000	38,000
Ash Content	12.93	2.11	0.4	2.0	1.6
Emission Rate	4.184	0.122	0.040	0.115	0.075

* Units are weight % for sulfur and ash, Btu/lb for heating value, and lb SO₂/10⁶ Btu for emission parameter.

† Units are weight %² for sulfur and ash, (Btu/lb)² for heating value, and (lb SO₂/10⁶ Btu)² for emission parameter.

semi-variogram for heating value is expected. Again the semi-variogram for emission parameter closely resembles that for sulfur and the variability in heating value appears not to have a marked effect.

Geostatistical Analysis - Republic Steel

Hourly Increment Study--

Figures 8-24 through 8-29 present the semi-variograms for the results of testing at Republic Steel during the 4-week long hourly increment study. By plotting the semi-variograms of raw coal and clean coal on the same graph, there is evidence that the variability of total sulfur, pyritic sulfur, and ash are attenuated by coal cleaning. The most notable difference is the amount of attenuation observed when coal is cleaned. In the case of total sulfur, the nugget constant was 0.077 for raw coal and only 0.005 for clean coal. Corresponding sill values were 0.090 and 0.007 (see Table 8-5). Unlike the R & F study, the variability of organic sulfur is reduced considerably. This is an unexpected result, since physical cleaning does not remove organic sulfur from the coal. A drift in the semi-variogram for organic sulfur indicates that a sill value does not exist.

30-Minute Increment Study--

For this 2-week intensive study, the sampling interval was 30 minutes. Both the support size (sampling interval) and the total time domain (lot size) were changed from the hourly, interval study. This allowed for a measurement of random and component variance for smaller lot sizes. Figures 8-30 through 8-35 present the semi-variograms for Republic Steel data collected during the 30-minute interval study. The reductions in variability of the clean coal for total sulfur, pyritic sulfur, and ash were again observed. The semi-variogram of organic sulfur for raw coal continued to show a drift, and no sill value existed. The nugget constants and sill values are presented in Table 8-6. Note the close agreement between the nugget constants for this study and the hourly interval study.

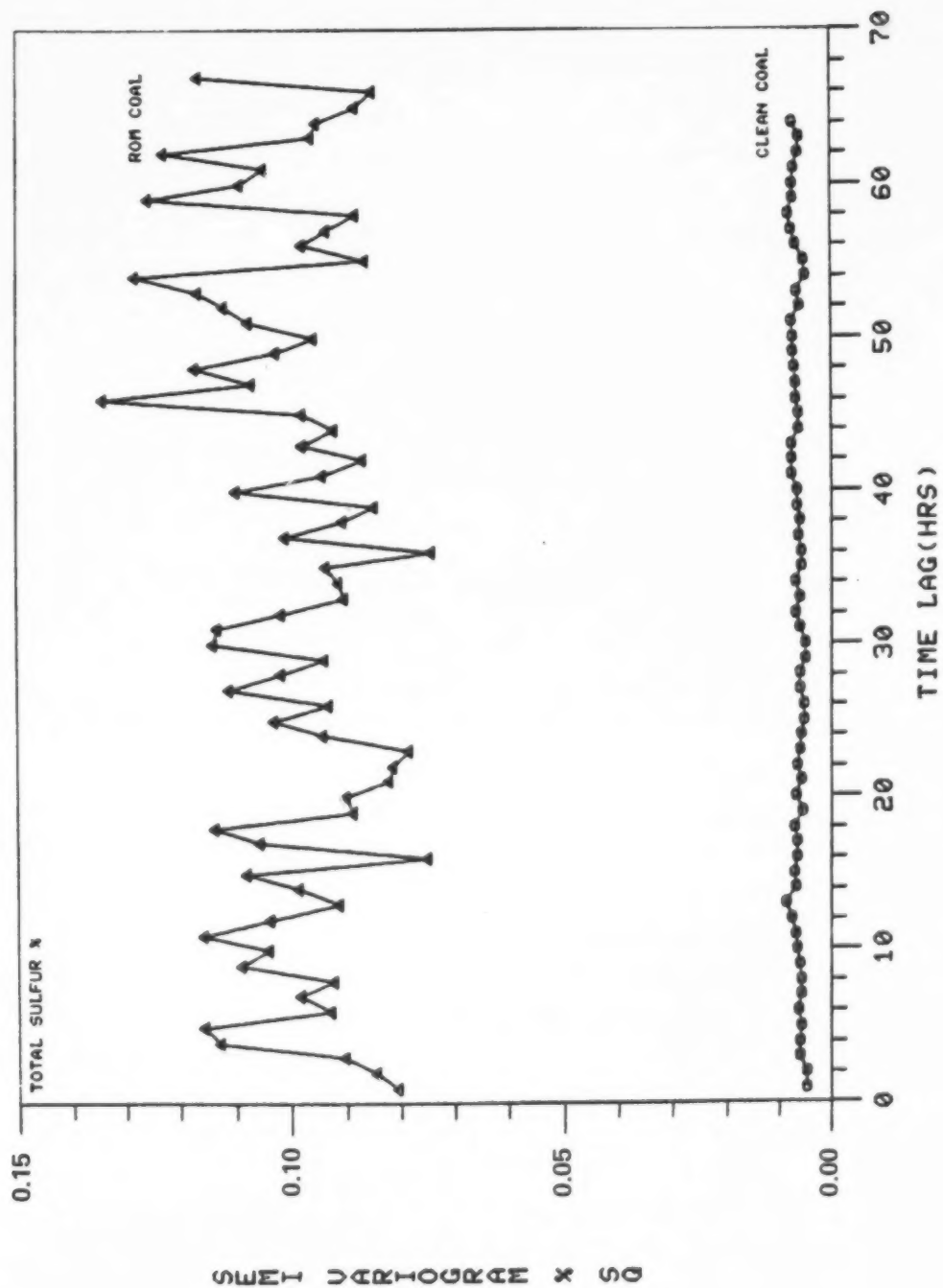


Figure 8-24. Republic Steel Corporation - semi-variogram of 1-hour increment data for total sulfur.

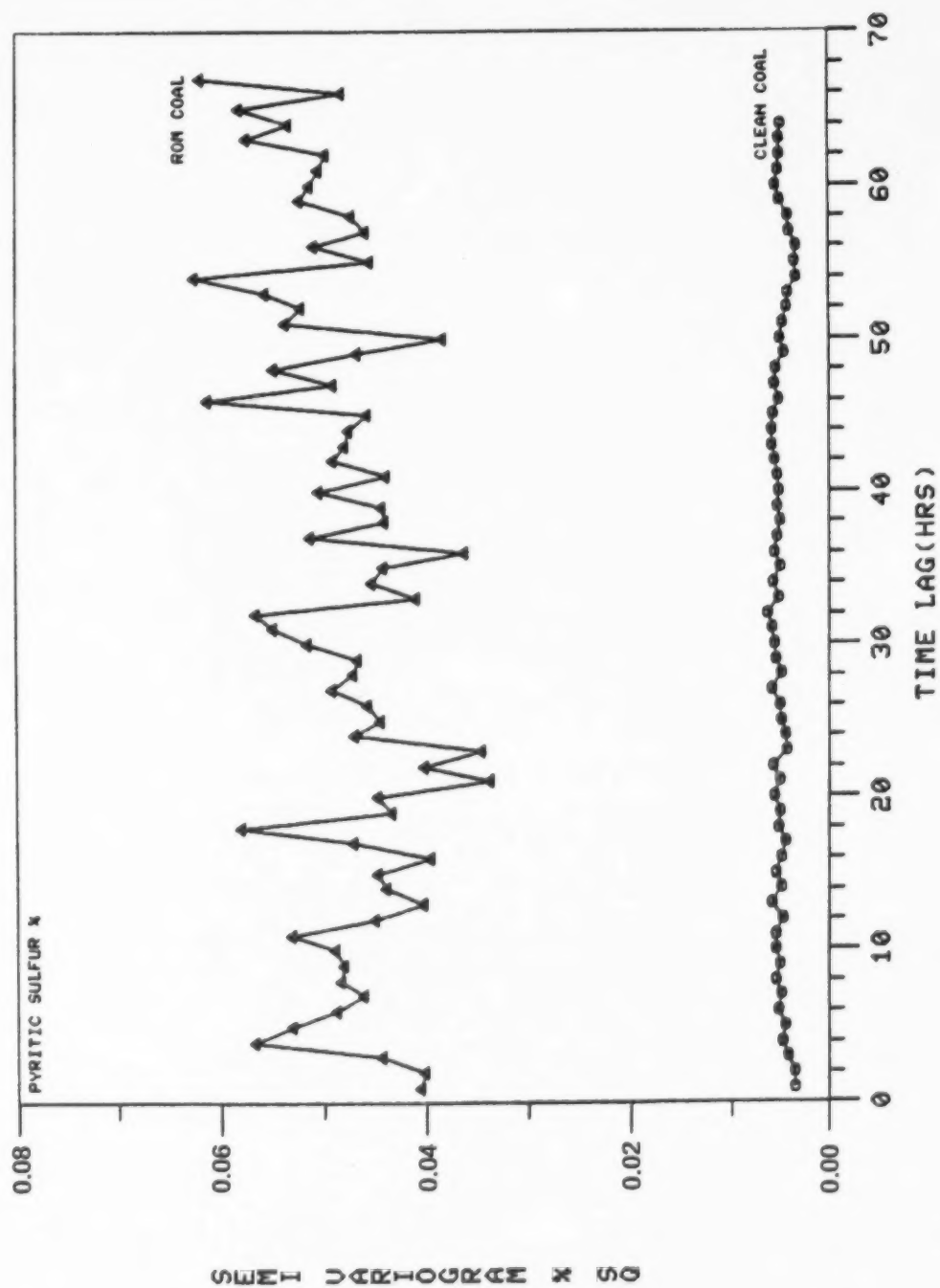


Figure 8-25. Republic Steel Corporation - semi-variogram of 1-hour increment data for pyritic sulfur.

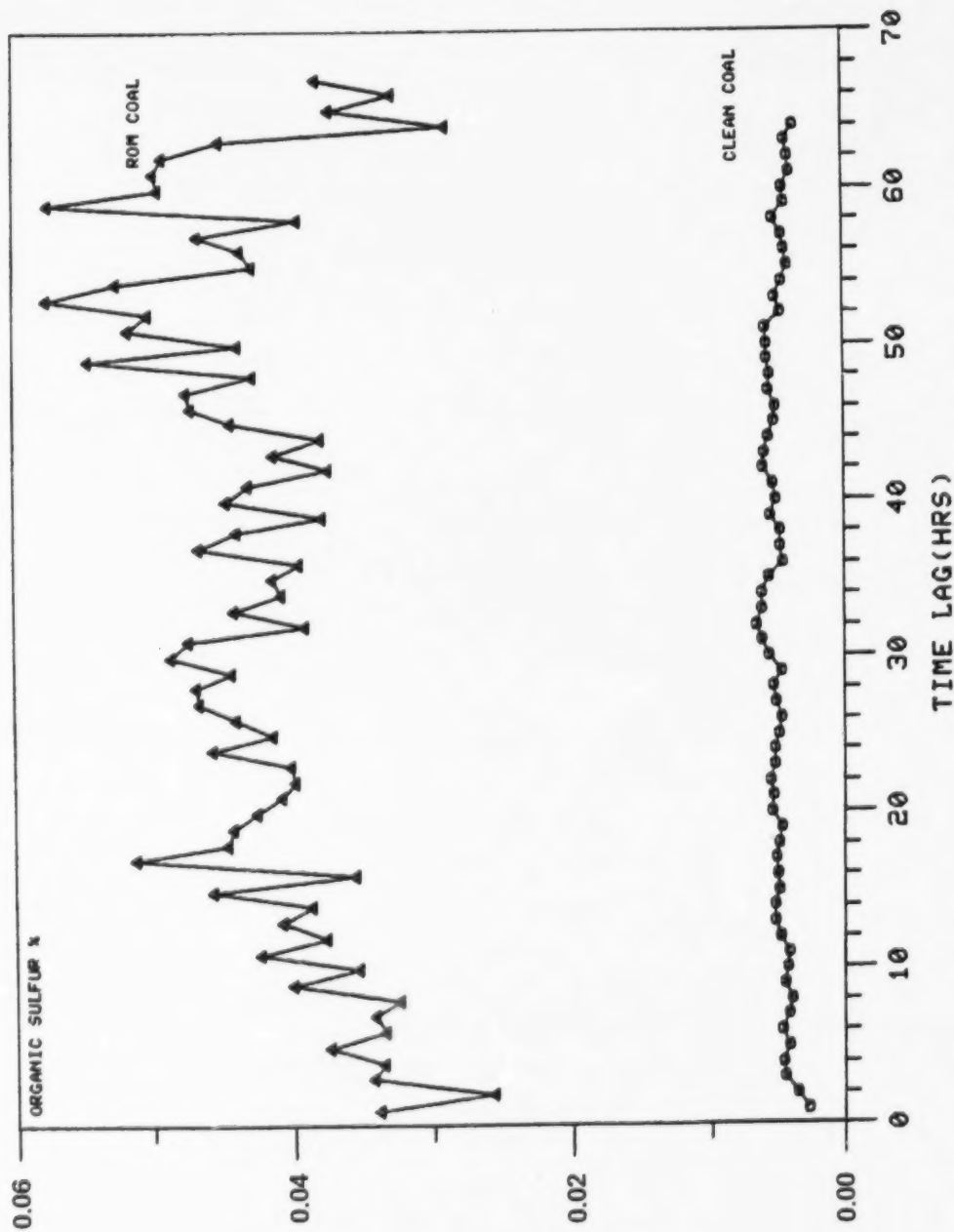


Figure 8 26. Republic Steel Corporation - semi-variogram of 1-hour increment data for organic sulfur.

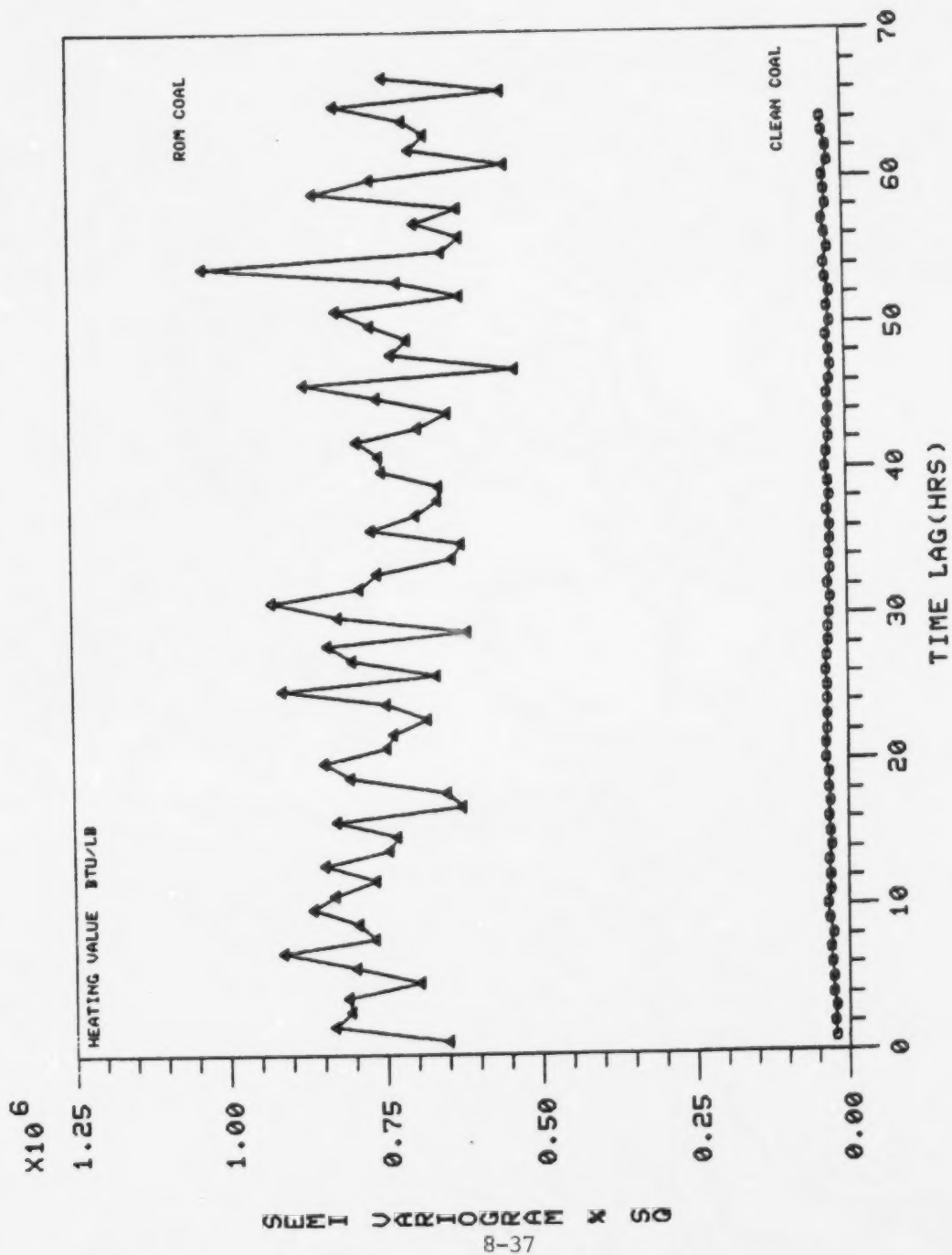


Figure 8-27. Republic Steel Corporation - semi-variogram of 1-hour increment data for heating value.

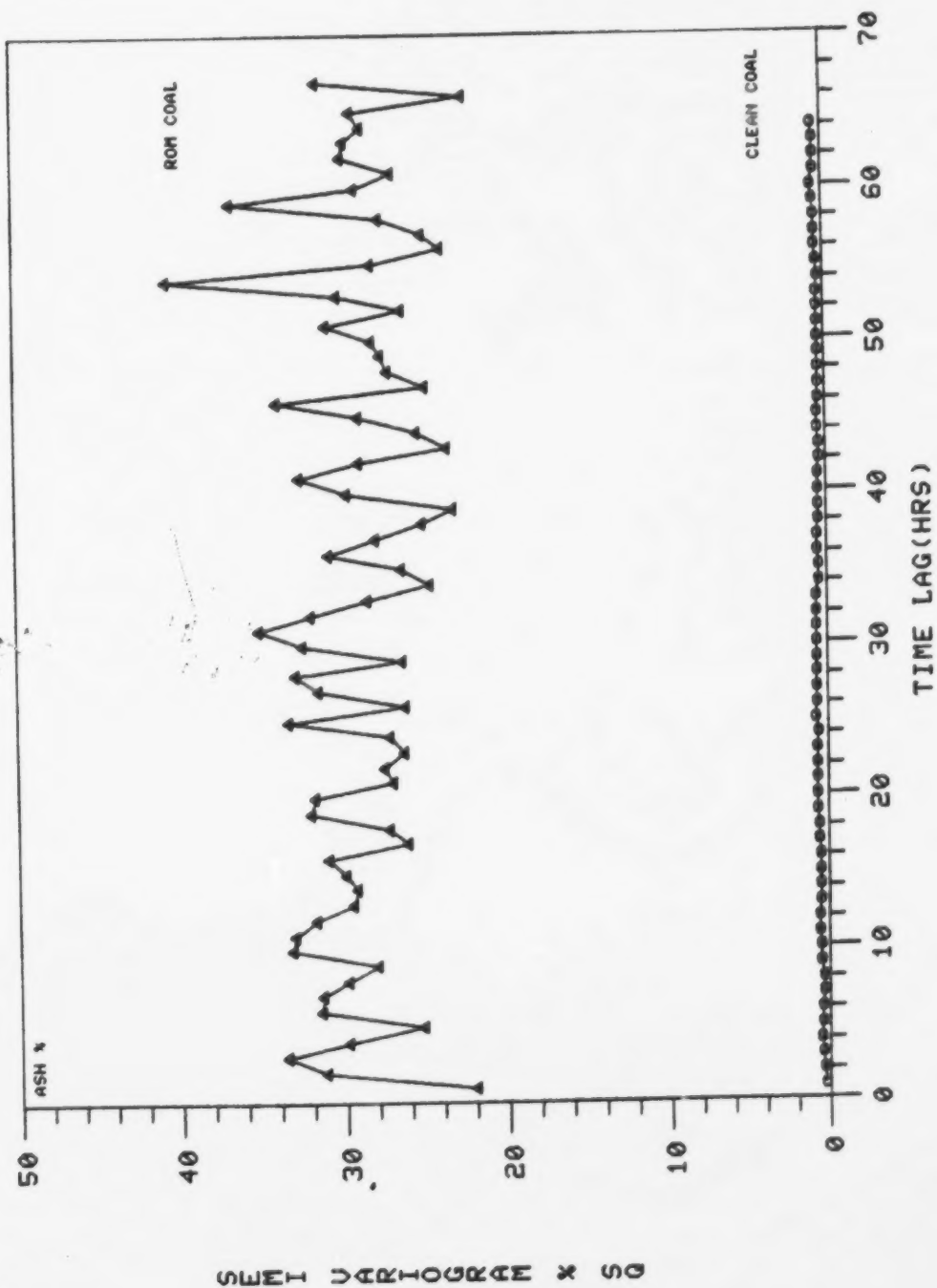


Figure 8-28. Republic Steel Corporation - semi-variogram of 1-hour increment data for ash content.

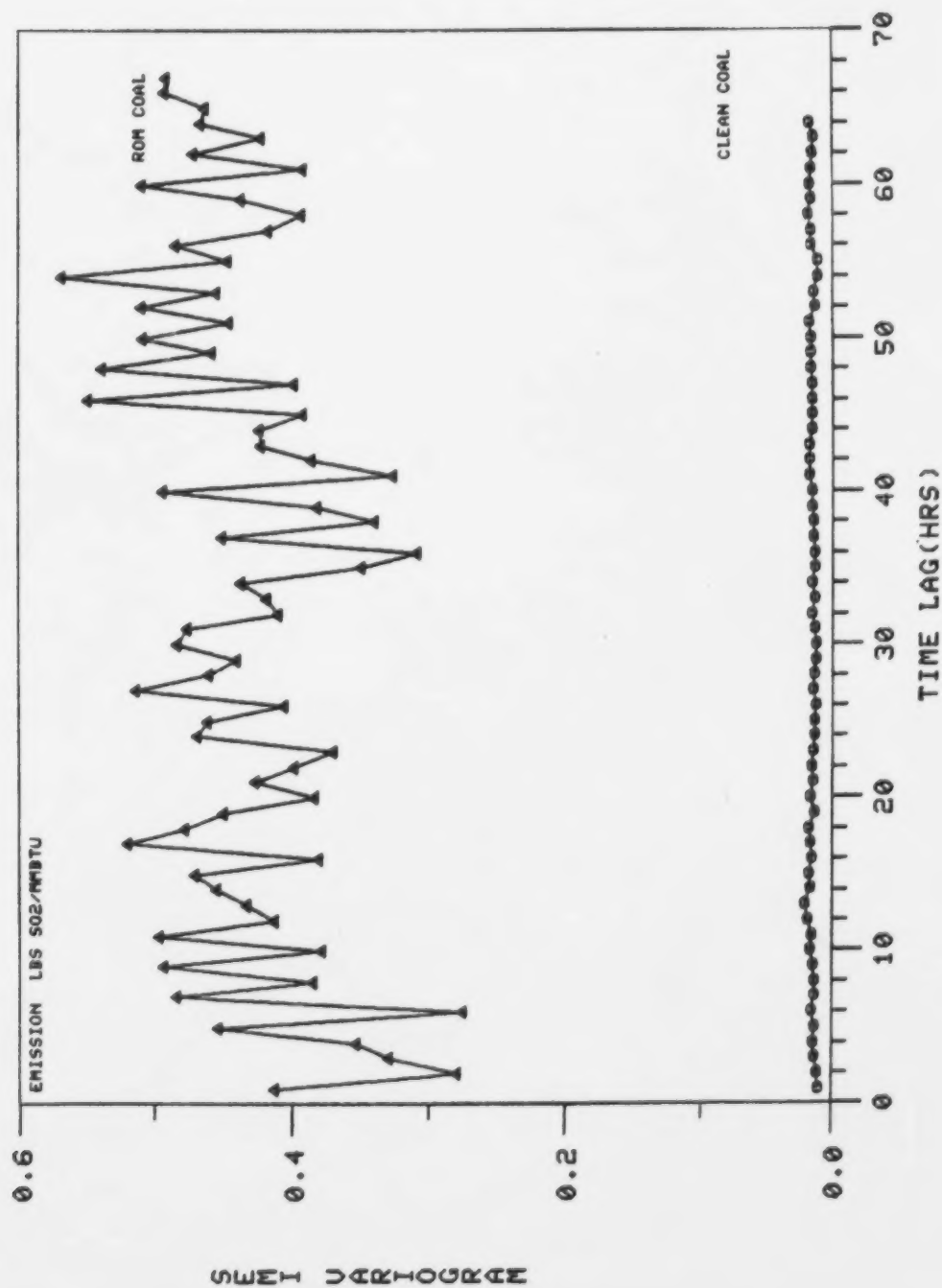


Figure 8-29. Republic Steel Corporation - semi-variogram of 1-hour increment data for sulfur dioxide emission rate.

TABLE 8-5. REPUBLIC STEEL CORPORATION - RANDOM AND CORRELATED VARIANCES
FOR HOURLY DATA (4 WEEKS)

ROM COAL SUMMARY						
	BASIC STATISTICS		GEOSTATISTICS			
	MEAN*	VARIANCE† S ²	NUGGET CONSTANT† C ₀	SILL VALUE† C ₀ +C	CORRELATED VARIANCE† C	
Total Sulfur	2.576	0.101	0.077	0.090	0.013	
Pyritic Sulfur	1.560	0.048	0.040	0.048	0.008	
Organic Sulfur	1.016	0.638	0.033	---	---	
Heating Value	10,098	774,382	467,100	750,000	282,900	
Ash Content	32.29	29.54	12.71	29.06	16.35	
Emission Rate	5.117	0.419	0.41	0.42	0.01	
CLEAN COAL SUMMARY						
Total Sulfur	1.309	0.007	0.005	0.007	0.002	
Pyritic Sulfur	0.558	0.005	0.003	0.005	0.002	
Organic Sulfur	0.752	0.005	0.002	0.005	0.003	
Heating Value	13,957	29,672	20,600	29,000	8,400	
Ash Content	9.367	0.61	0.15	0.55	0.40	
Emission Rate	1.875	0.017	0.011	0.016	0.005	

* Units are weight % for sulfur and ash, Btu/lb for heating value, and lb SO₂/10⁶ Btu for emission parameter.

† Units are weight %² for sulfur and ash, (Btu/lb)² for heating value, and (lb SO₂/10⁶ Btu)² for emission parameter.

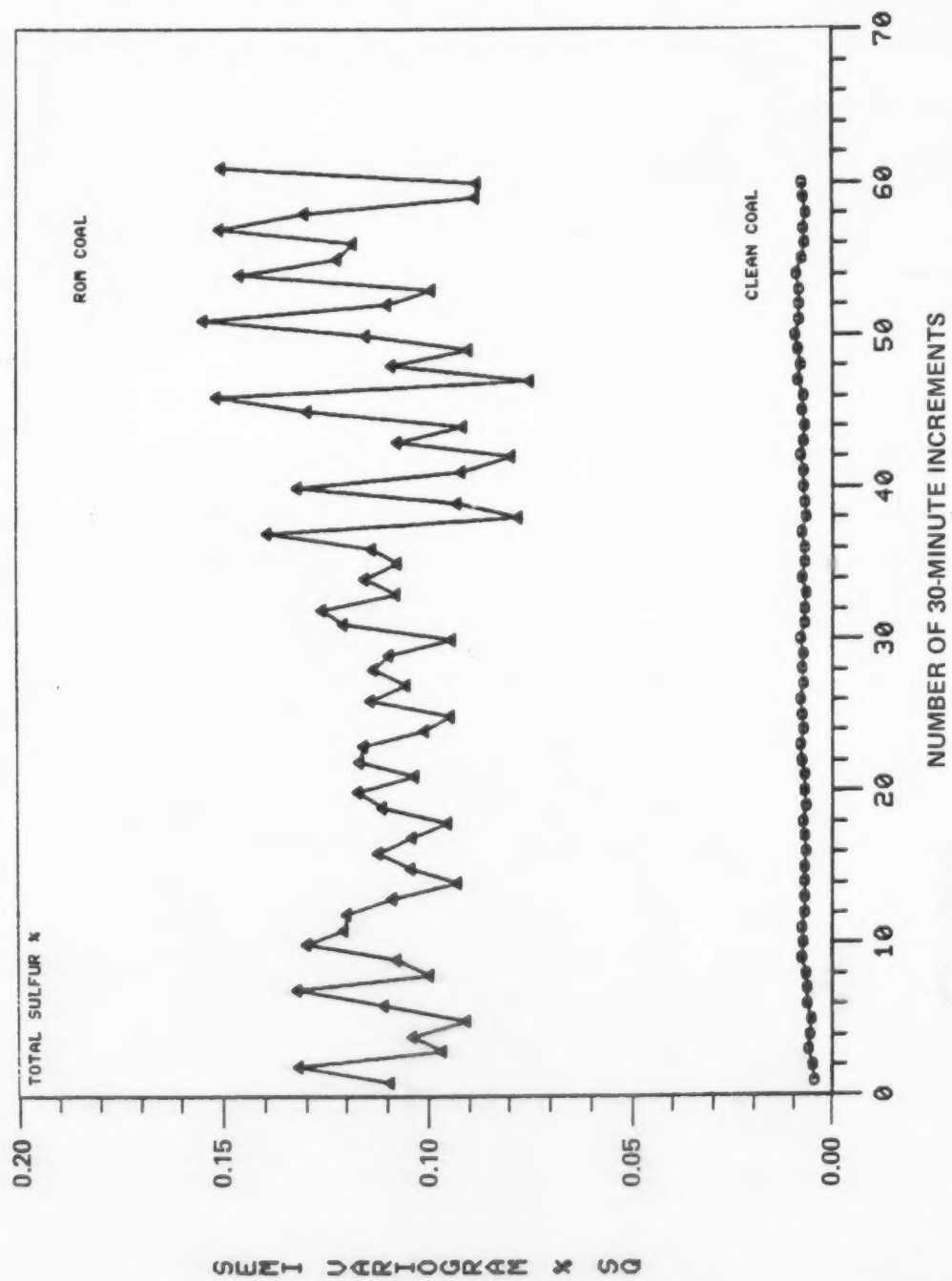


Figure 8-30. Republic Steel Corporation - semi-variogram of half-hour data for total sulfur.

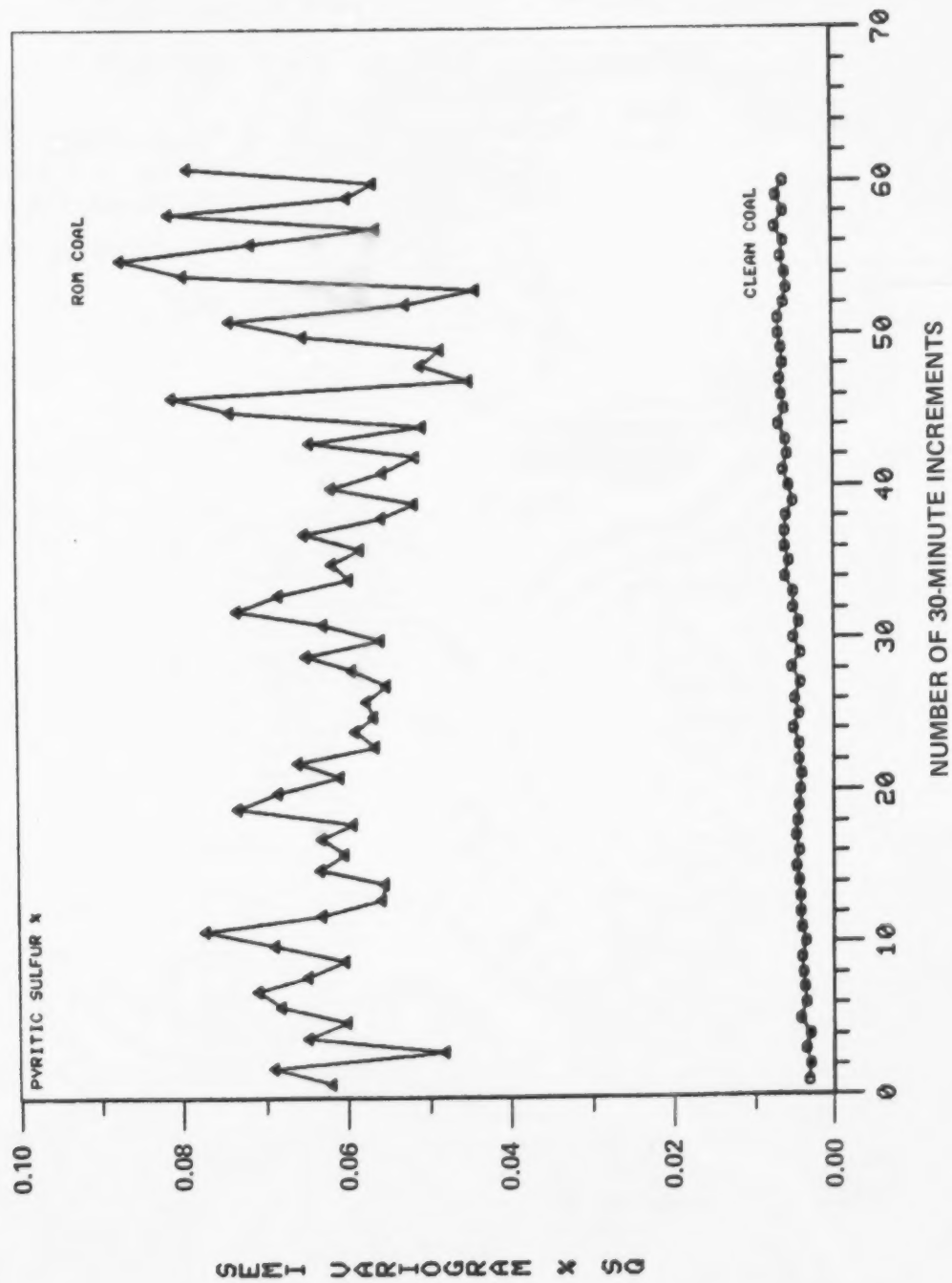


Figure 8-31. Republic Steel Corporation - semi-variogram of half-hour data for pyritic sulfur.

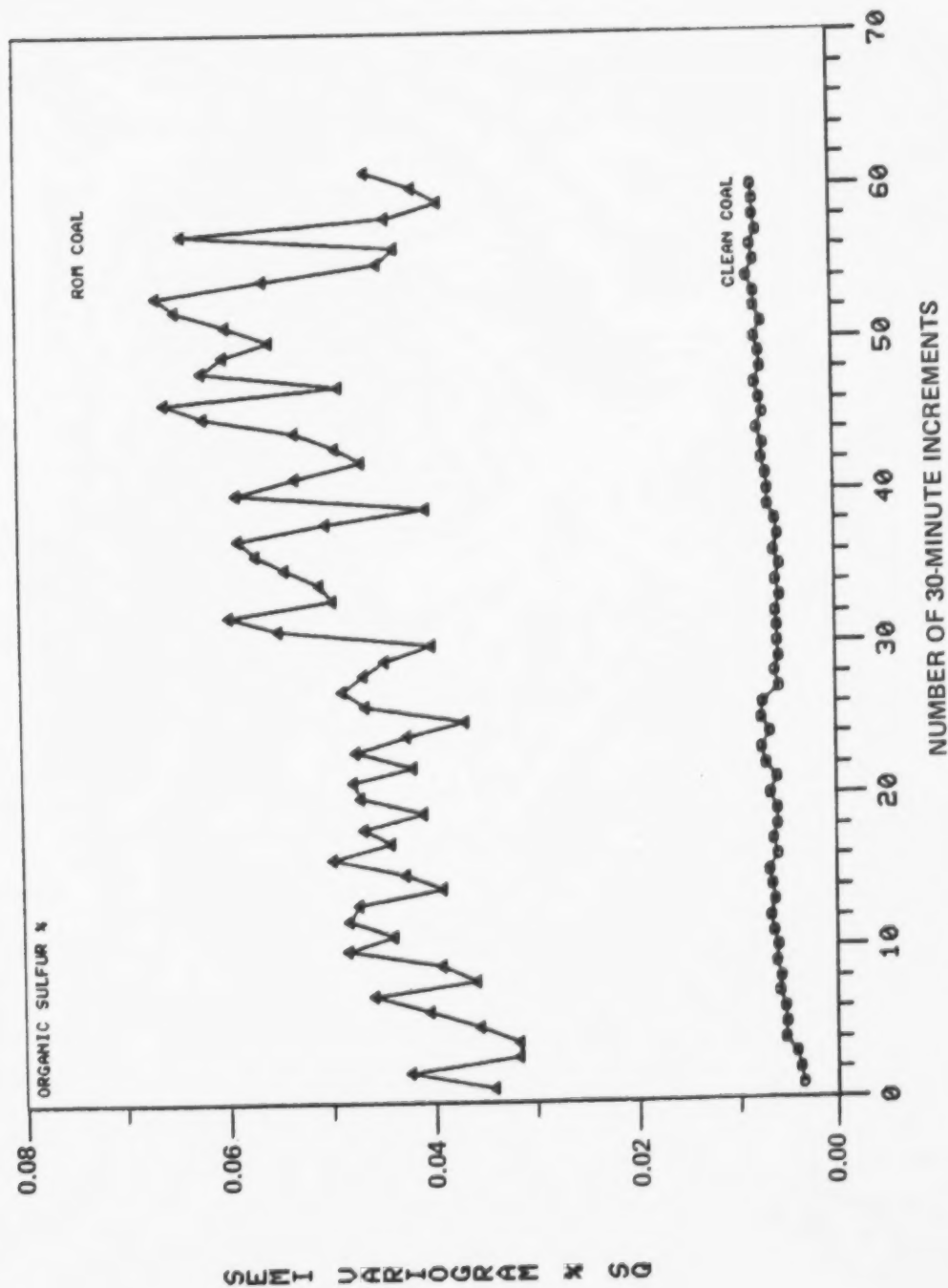


Figure 8-32. Republic Steel Corporation - semi-variogram of half-hour data for organic sulfur.

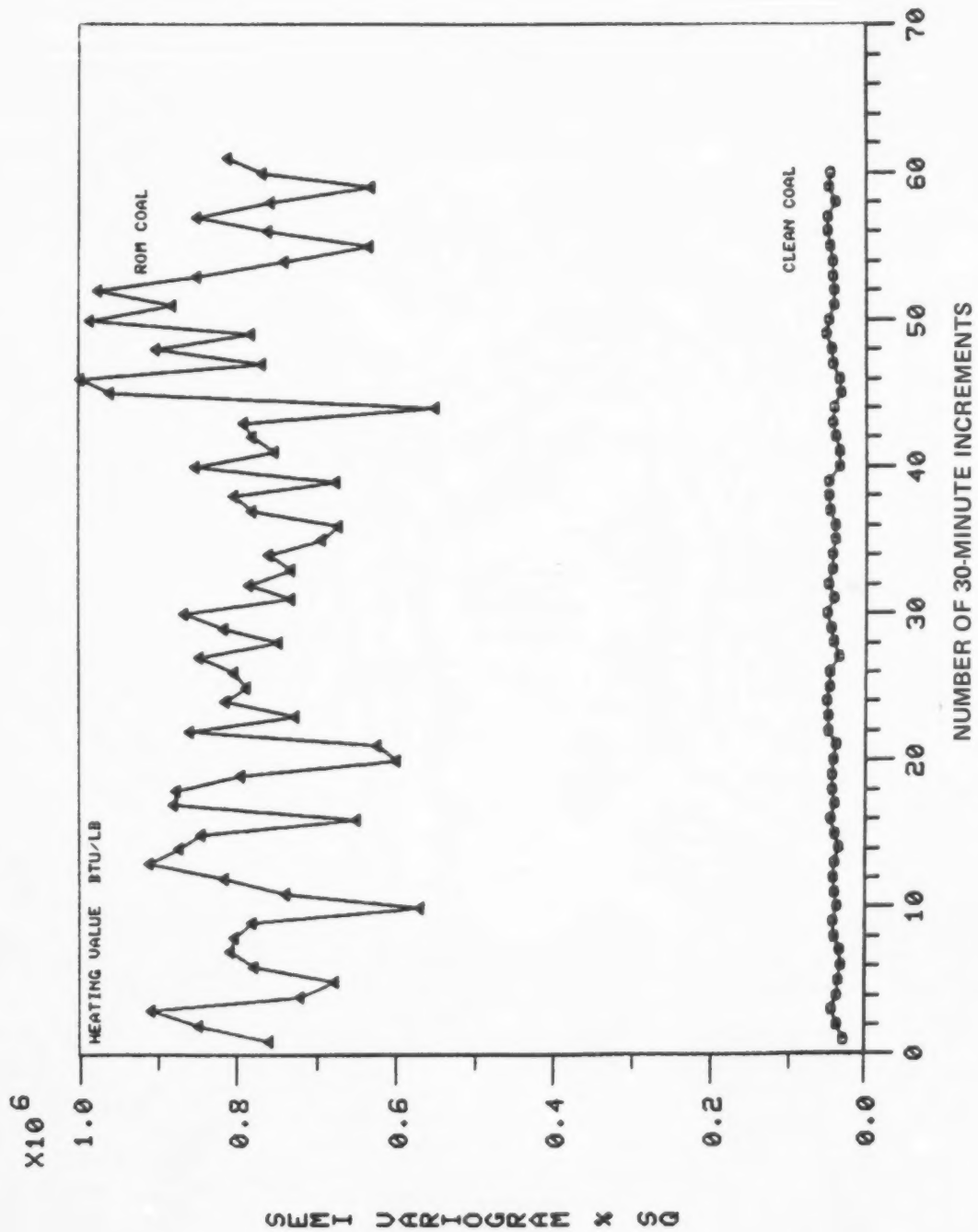


Figure 8-33. Republic Steel Corporation - semi-variogram of half-hour data for heating value.

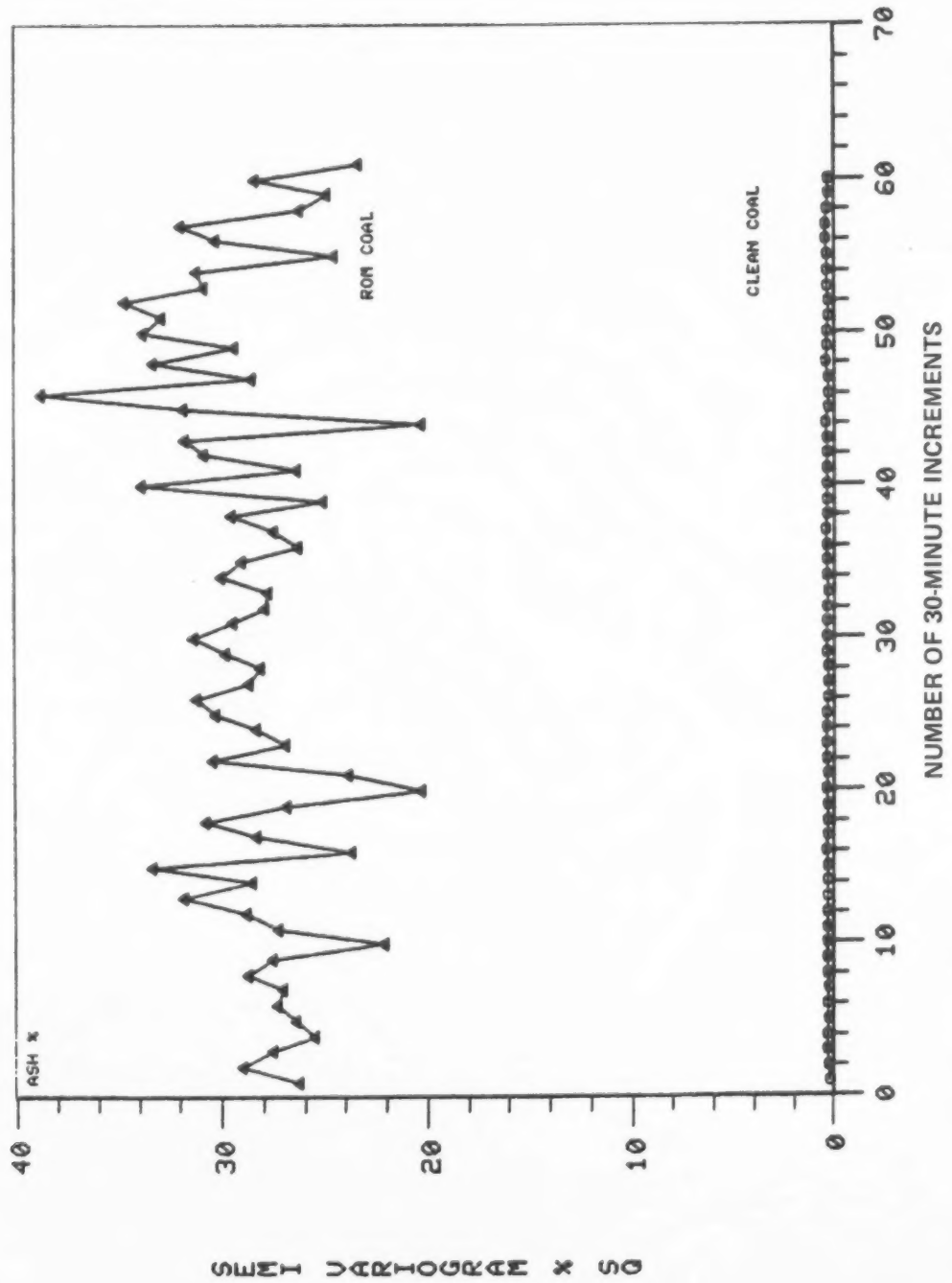


Figure 8-34. Republic Steel Corporation - semi-variogram of half-hour data for ash content.

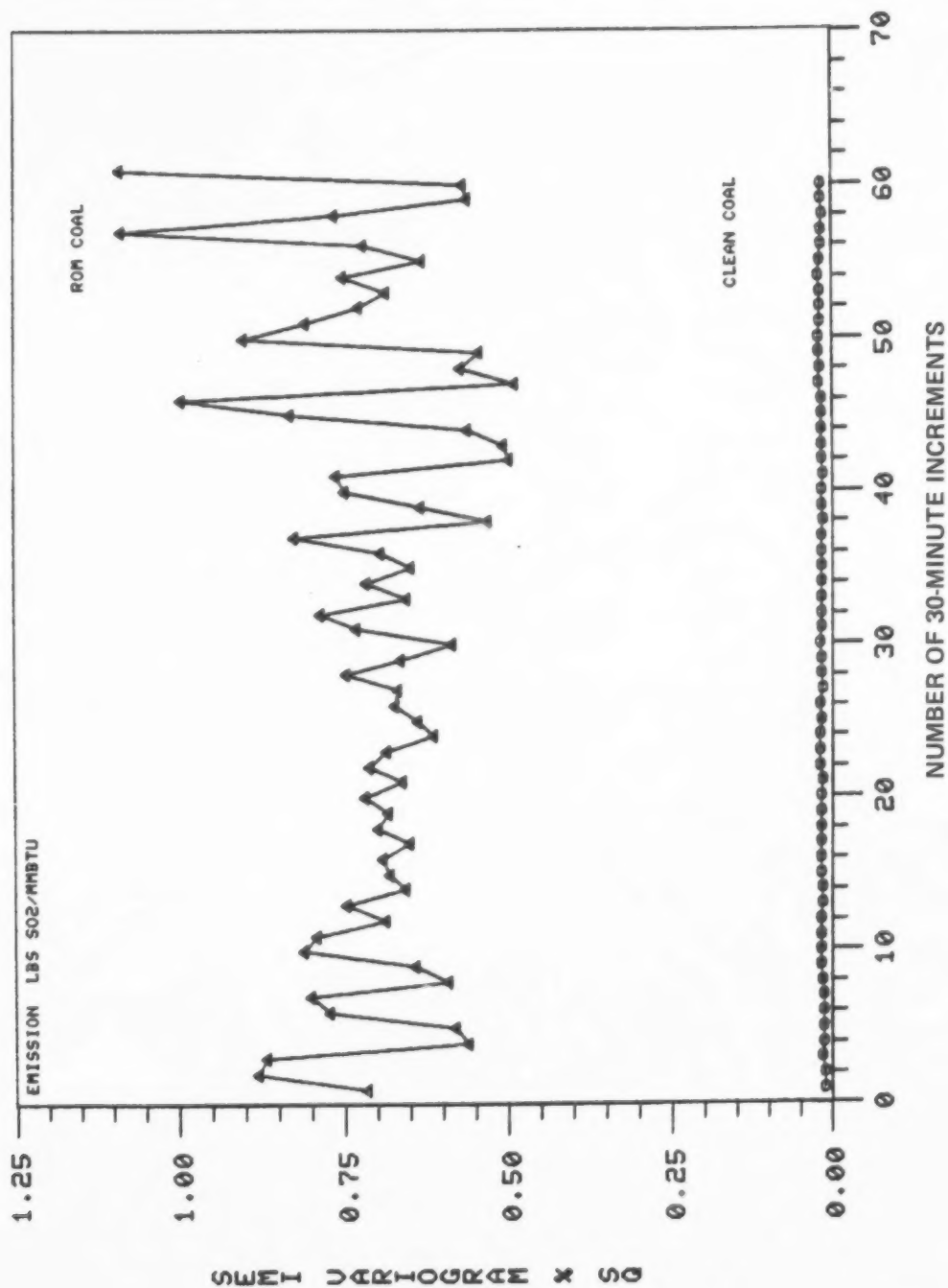


Figure 8-35. Republic Steel Corporation - semi-variogram of half-hour data for sulfur dioxide emission rate.

TABLE 8-6. REPUBLIC STEEL CORPORATION - RANDOM AND CORRELATED VARIANCES
FOR HALF-HOUR DATA (2 WEEKS)

		ROM COAL SUMMARY			
		BASIC STATISTICS		GEOSTATISTICS	
	MEAN*	VARIANCE†	NUGGET CONSTANT†	SILL VALUE†	CORRELATED VARIANCE†
	x	S ²	C ₀	C ₀ +C	C
Total Sulfur	2.643	0.113	0.087	0.110	0.023
Pyritic Sulfur	1.588	0.060	0.055	0.060	0.005
Organic Sulfur	1.018	0.045	0.026	---	---
Heating Value	9,946.	762,976.	670,000.	760,000.	90,000
Ash Content	32.91	27.05	23.57	27.00	3.43
Emission Rate	5.350	0.735	0.55	0.70	0.15
CLEAN COAL SUMMARY					
Total Sulfur	1.304	0.007	0.005	0.007	0.002
Pyritic Sulfur	0.545	0.005	0.003	0.005	0.002
Organic Sulfur	0.758	0.006	0.003	0.006	0.003
Heating Value	13,957.	38,353.	20,400.	38,000.	17,600
Ash Content	9.180	0.327	0.148	0.320	0.172
Emission Rate	1.867	0.017	0.011	0.017	0.006

* Units are weight % for sulfur and ash, Btu/lb for heating value, and lb SO₂/10⁶ Btu for emission parameter.

† Units are weight %² for sulfur and ash, (Btu/lb)² for heating value, and (lb SO₂/10⁶ Btu)² for emission parameter.

SUMMARY OF GEOSTATISTICAL ANALYSIS

The technique of geostatistics has been used to quantify the correlated and random components of the variability in coal data. The correlated variance and random variance have been determined graphically from the experimental semi-variograms.

It is found that ROM coal data exhibit more variability than the corresponding clean coal data. This observation is evident from an inspection of experimental semi-variograms for total sulfur which show that ROM coal data have larger sill values and smaller ranges of influence. The attenuation of sulfur variability can be attributed to the removal of pyrite and ash in the coal cleaning process, because pyrite and ash appear as discrete particles and contribute to the randomness in coal data.

The power of geostatistics lies in its ability to interpolate data with both correlated and random components. Extrapolation of such data must be handled by an alternative technique such as Time Series Analysis, shown in the following section.

SECTION 9.0

TIME SERIES ANALYSIS

INTRODUCTION OF MODELS FOR DISCRETE TIME SERIES

Techniques used to deal with correlated data that are measured at discrete, equally spaced intervals are called time series analyses. These techniques explore the correlation structure and sometimes allow future values to be predicted within a narrow range of confidence limits. A complete discussion of time series can be found in the book entitled "Time Series Analysis: Forecasting and Control" by Box and Jenkins.⁽⁸⁾

TYPES OF MODELS

Time series are defined as either non-stationary or stationary. Non-stationary processes have a varying mean that changes with time. Stationary time series have a fixed mean, and vary about that mean in a manner that does not change with time, i.e., the variance and the correlation structure are not functions of time. A visual inspection of the coal sampling data shows that they exhibit stationary time series characteristics. A time series can be further categorized as an autoregressive process, moving average process, or a mixed process. The models used in the following analyses are Auto-Regressive Integrated Moving Average (ARIMA) models.

Autoregression Processes

An autoregressive process of order P, AR(p), may be represented by an equation of the form:

$$w_t = \phi_1 w_{t-1} + \phi_2 w_{t-2} + \dots + \phi_p w_{t-p} + a_t + \theta_0$$

where:

W_t = the value of the time series at time t

W_{t-n} = the value of the time series at time $t-n$, $n=1, 2, \dots, p$

$\phi_1, \phi_2, \dots, \phi_p$ = autoregressive parameters of the time series

a_t = a random shock to the system at time t , also termed the residual

θ_0 = a constant of the process, called the overall moving average constant

A model is termed autoregressive if the value of the time series at time t is dependent upon past values of the time series itself. This dependence is accounted for by the autoregressive, or " ϕ " parameters. The values of the parameters ϕ_n , as well as the number " p " of these parameters must be estimated from the data set. The random number a_t accounts for the non-structured portion of the time series.

Moving Average Processes

A moving average process of order q , $MA(q)$, may be represented by an equation of the form:

$$W_t = \theta_0 + a_t - \theta_1 a_{t-1} - \theta_2 a_{t-2} - \dots - \theta_q a_{t-q}$$

where:

W_t , θ_0 , and a_t are as defined above.

a_{t-n} = the random shock generated at time $t-n$, $n = 1, 2, \dots, q$

$\theta_1, \theta_2, \dots, \theta_q$ = moving average parameters of the time series

The name "moving average" for this type of process is misleading because the mean of the process does not, in fact, change, but the terminology is well established so it will be employed throughout this report. The moving average, or " θ " parameters, account for the fact that a shock to or change in the system at time " t " may also affect the system at some future time. The numerical values for the moving average parameters and the number of these parameters must be estimated by analyzing the data set.

Mixed Processes

Mixed processes exhibit both autoregressive and moving average characteristics. Processes of order p, q, ARMA (p, q), can be represented by an equation of the form:

$$w_t = \theta_0 + a_t + \sum_{i=1}^p \phi_i w_{t-i} - \sum_{j=1}^q \theta_{t-j}$$

where all variables have the same meaning as those given in the preceding sections.

Model Building Procedures

Estimating the parameters necessary to adequately describe a time series is a complex procedure that requires several iterative steps. The procedures for model building usually consist of model identification, model fitting of experimental data, and diagnostic checks. These procedures described beginning on page 9-12, were used with sampling data from the two preparation plants. After performing these iterative steps, an 'optimum' model is generated.

Time Series Generation

One application of the optimum model is to generate additional terms of the time series. This is useful for more accurately estimating various statistical parameters associated with the time series that has been modeled. As an example, the data sets B and C from the R&F plant were gathered from a coal stream that would supply a moderate-sized coal-fired power plant for approximately two or three days. Predicting from three days of data the daily average sulfur emissions that would be produced by such a power plant over a year is obviously an impossible task. However, by using the model to generate predicted values from these data points with a distribution the same as that of the original data points (including the correlation factor) permits one to estimate future emission values.

Additional points may be generated through use of one of the applicable formulas previously defined in this section. The residuals (a_t) used in these formulas are produced by a random number generator and have a

zero mean, and a Gaussian distribution. Terms in the series are generated by direct application of the time series formulas. The following analysis of an experimental data set for total sulfur (in weight percent) illustrates a time series generation and how it determines expected values. Suppose the mean value $\bar{x}$ for the experimental data is 3.22 and the total variance S^2 is 0.1421. An autoregressive model of order 2 has been found to fit this set of data, and optimum parameter estimates have been found as follows:

$$W_t = \phi_1 W_{t-1} + \phi_2 W_{t-2} + a_t + \theta_0$$

where:

$$\phi_1 = 0.3669, \phi_2 = 0.2052, \theta_0 = 1.3780,$$

$$\text{white noise variance (WNV)} = 0.1031$$

Consider the situation where the sulfur values were 3.4 and 3.1 at last half hour and one hour. Substituting the figures in the above equation provides an estimate of present value:

$$W_t = 3.26 + a_t$$

The expected value of W_t is 3.26, because the mean value of a_t is zero by definition. Furthermore, at 95 percent confidence level, the confidence limits are

$$\{3.26 \pm 2\sqrt{\text{WNV}}\} \text{ or } \{2.62, 3.90\}.$$

If the same data were treated as uncorrelated, the expected value would be the mean value 3.22, and the 95 percent confidence limits would be

$$\{\bar{x} \pm 2 S\} \text{ or } \{2.47, 3.97\}.$$

This example illustrates that if correlation exists, the expected value is changed from the mean value because of the correlated structure, and the range of confidence limits is smaller. A smaller confidence limit means that a better estimation of the expected value is obtained by taking correlation into account.

EXPERIMENTAL DATA USED IN TIME SERIES ANALYSIS

Description of Data Sets

Three data sets were analyzed by time series analysis. The first data set was from a 22 hour, 30-minute increment study at R&F (sample code A), the second data set is from the 40 hour, 30-minute increment study at R&F (sample code B & C), and the third data set is hourly data from Republic Steel. The criteria for selecting a data set for time series analysis are: (1) more than 40 points in the data store with few missing data points, and (2) the data set selected has been shown to be correlated according to Crow's test of autocorrelation.

To further concentrate the effort, only three parameters (total sulfur, ash, and emission rate) were chosen for time series analysis of the ROM coal and clean coal. Thus a total of 18 ($3 \times 3 \times 2$) parameters was analyzed, producing 18 ARIMA (Box-Jenkins) models.

Data Set Modifications

The data sets presented in Appendix A show that there are missing data points in almost every set. Unfortunately, the present version of the ARIMA (Box-Jenkins) model in the International Mathematical Statistical Library (IMSL) does not allow a reasonable treatment of missing data. For the purpose of model fitting, treating these missing data as zeros would not yield meaningful results (i.e., would produce unrealistically high variances). Ignoring missing data entirely changes the time sequence in the data. Two ways were used to circumvent this difficulty:

- (1) In the case where missing data occur near the end points of the data set, one can delete the relatively short data strings, producing a truncated data set.
- (2) If the data are not near end points of the set, one can fill in isolated missing data points with reasonable estimates. For example, replace the missing data by the local averages of two preceding and two following data points. The rationale is that the parameter determination in model building may not be sensitive to the values replaced, so long as they are reasonable. Ideally, this scheme of handling missing data must be justified a posteriori after the model building.

These techniques were used to modify the experimental data from R&F and Republic as described below.

22-Hour Increment Study--

No modification was made to the raw coal data and all 44 data points were used. However, for the clean coal, the missing data for samples A207 and A231 were filled in by the local averages as outlined above. The clean coal data set contains 43 points.

The modified data sets are displayed in Table 9-1, with sample values given on a dry basis. Figure 9-1 is a plot of emission rate versus production time both for ROM coal and clean coal.

40-Hour Increment Study--

For the ROM coal data set, the samples from B101 through B117 were left out, because this is a short string with missing data and occurs at the beginning of the 40-hour data set. The modified data set begins with sample code B118 and contains 63 points.

The sample values of total sulfur and emission parameter for point C110 were unusually high, although this data point passed the test of quality control and seemed to be a correct value. However, the sample values were so different from the mean (about $\bar{x} + 5 S$), that the model type and/or parameter values of the ARIMA model were very sensitive to its presence. It was decided to move the sample values to $(\bar{x} + 3 S)$ instead. Thus the sulfur value was moved from 5.76 to 4.64, and the heating value was moved from 11012 to 8250.

Furthermore, the sample values of B127 and B227 seemed to indicate that the clean coal has higher sulfur, higher ash, and lower heating value than the raw coal. These sample values strongly suggested that the data from this matched pair were switched, i.e., samples were mislabelled. Rather than switch or treat as unusual data to be moved, it was decided to replace these data by local averages.

Finally, missing data were filled in for the clean coal samples B237 and C212. The data sets used in the time series are displayed in Table 9-2.

TABLE 9-1. DATA USED IN TIME SERIES ANALYSIS-R&F COAL COMPANY, 30-MINUTE INCREMENT DATA FOR 22 HOURS, ROM COAL AND CLEAN COAL, DRY BASIS

DATA SET A, ROM COAL, 30-MINUTE DATA, RLF COAL CO.					DATA SET A, CLEAN COAL, 30-MINUTE DATA, RLF COAL CO.						
CODE	TS	ASH	S02	CODE	TS	ASH	S02	CODE	TS	ASH	S02
A141	3.19	14.90	5.61	A123	2.95	21.66	5.36	A223	2.46	13.52	4.85
A142	2.80	16.28	5.57	A124	2.46	21.91	4.78	A224	2.23	13.46	3.62
A143	2.92	16.00	5.54	A125	2.79	21.79	4.93	A225	2.47	14.12	4.07
A144	2.90	15.83	5.50	A126	2.82	22.16	4.96	A226	2.29	13.57	3.74
A145	2.98	17.04	5.36	A127	2.54	21.11	4.47	A227	2.29	14.27	3.73
A146	3.06	17.46	5.53	A128	2.60	21.71	4.65	A228	2.29	13.96	3.76
A147	3.11	16.66	5.64	A129	2.50	23.36	4.53	A229	2.46	14.30	4.05
A148	3.26	17.77	5.98	A130	2.57	23.23	4.67	A230	2.39	14.10	3.86
A149	2.83	22.23	5.13	A131	2.55	22.34	4.57	A231	2.43	13.46	3.99
A150	2.70	22.13	4.80	A132	2.63	21.74	4.67	A232	2.49	12.91	3.98
A151	2.74	22.04	4.84	A133	2.70	22.76	4.91	A233	2.38	12.52	4.66
A152	2.74	21.83	4.93	A134	2.90	23.51	5.14	A234	2.64	13.02	4.50
A153	2.56	20.95	4.57	A135	3.20	20.72	5.78	A235	2.42	12.62	4.05
A154	2.52	20.64	4.49	A136	3.01	20.73	5.49	A236	2.48	13.34	4.01
A155	2.33	20.75	4.16	A137	3.01	20.91	5.43	A237	2.54	13.41	4.04
A156	2.74	20.68	4.05	A138	3.01	21.08	5.42	A238	2.43	13.93	3.96
A157	2.76	20.11	4.87	A139	3.09	19.72	5.31	A239	2.47	14.92	4.00
A158	2.73	19.78	4.81	A140	3.01	21.95	5.46	A240	2.40	13.93	3.88
A159	2.92	19.11	5.15	A141	2.82	22.50	5.21	A241	2.20	13.81	3.74
A160	2.97	22.08	5.35	A142	2.72	22.04	4.99	A242	2.45	13.36	4.00
A161	2.84	21.10	5.10	A143	2.75	20.89	5.15	A243	2.39	13.60	3.90
A162	3.02	21.32	5.40	A144	2.83	22.13	5.15				

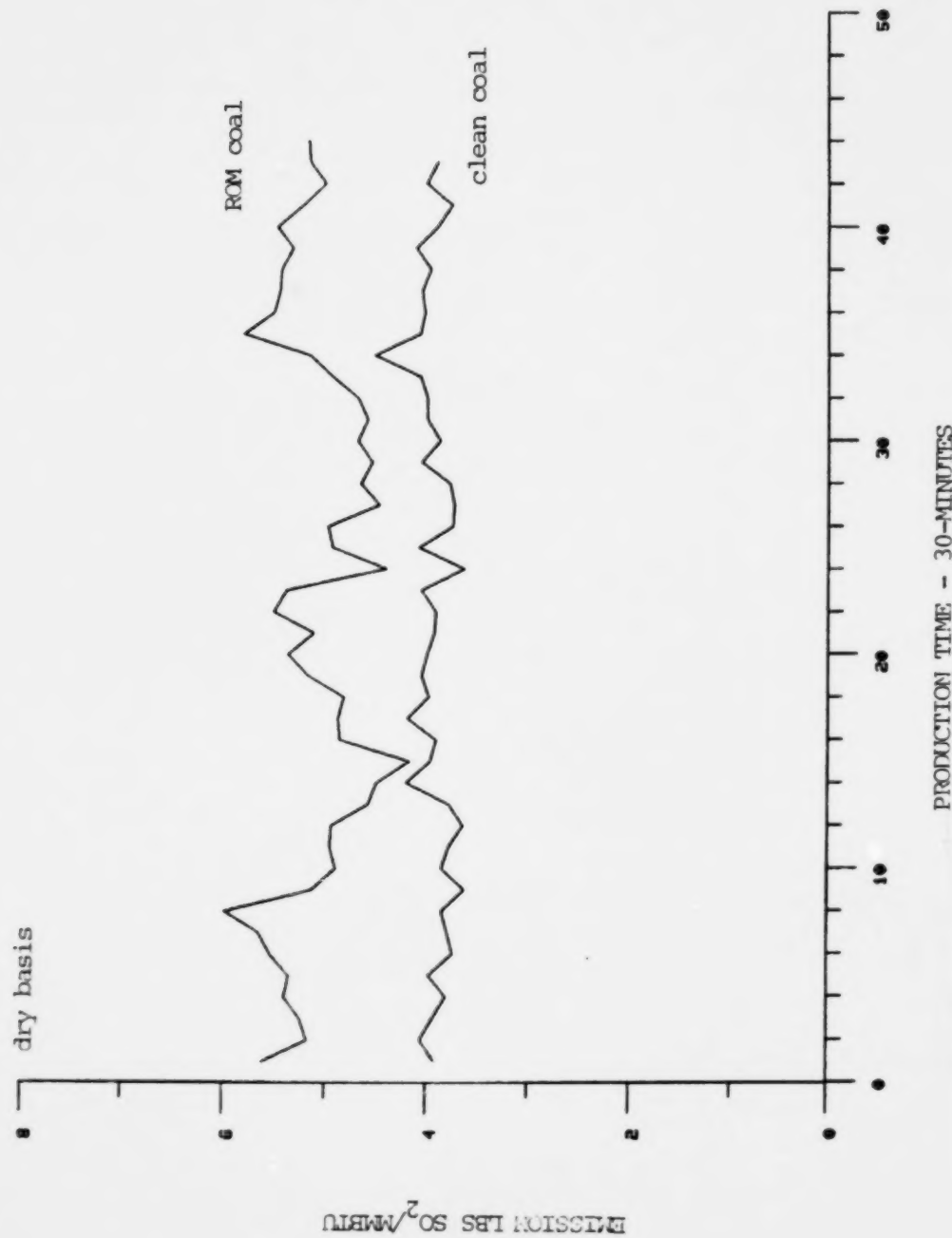


Figure 9-1. R&F Coal Company - 22-hour increment study, emission rate and ROM coal and clean coal. Time series analysis.

TABLE 9-2. DATA USED IN TIME SERIES ANALYSIS-R&F COMPANY, 30-MINUTE INCREMENT DATA FOR 40 HOURS, ROM COAL AND CLEAN COAL, DRY BASIS

DATA SETS B & C, CLEAN COAL, 30-MINUTE DATA, R&F COAL CO.											
CODE	TS	ASH	S02	CODE	TS	ASH	S02	CODE	TS	ASH	S02
B241	2.86	11.00	4.49	B201	2.53	15.88	4.10	B241	2.86	11.00	4.49
B242	2.92	6.97	4.67	B202	2.65	14.23	4.31	B242	2.92	6.97	4.67
B243	3.03	7.04	4.80	B203	2.92	14.98	4.82	B243	3.03	7.04	4.80
B244	3.15	7.60	4.96	B204	2.55	12.18	4.69	B244	3.15	7.60	4.96
B245	2.95	6.86	4.63	B205	2.62	12.83	4.20	B245	2.95	6.86	4.63
B246	2.40	8.26	3.77	B206	2.51	12.96	4.60	B246	2.40	8.26	3.77
B247	2.42	8.50	3.93	B207	2.67	11.64	4.38	B247	2.42	8.50	3.93
B248	3.08	8.85	5.03	B208	2.67	11.49	4.27	B248	3.08	8.85	5.03
B249	2.58	11.32	4.27	B209	2.77	11.79	3.74	B249	2.58	11.32	4.27
B250	2.58	11.32	4.27	B210	2.80	11.84	4.46	B250	2.58	11.32	4.27
B251	2.60	10.97	4.40	B211	3.03	10.50	4.71	B251	2.60	10.97	4.40
B252	2.73	10.73	5.35	B212	3.06	11.26	4.80	B252	2.73	10.73	5.35
B253	2.73	10.73	5.35	B213	3.14	12.68	5.13	B253	2.73	10.73	5.35
B254	3.12	9.82	5.07	B214	2.78	11.75	4.41	B254	3.12	9.82	5.07
B255	3.02	9.39	4.92	B215	2.15	13.55	4.96	B255	3.02	9.39	4.92
B256	3.49	9.69	5.80	B216	2.62	13.24	4.28	B256	3.49	9.69	5.80
B257	3.20	9.82	5.32	B217	2.72	12.86	4.33	B257	3.20	9.82	5.32
B258	3.57	9.01	5.65	B218	2.91	12.15	4.67	B258	3.57	9.01	5.65
B259	2.75	12.50	4.36	B219	2.44	11.67	3.95	B259	2.75	12.50	4.36
B260	2.91	12.16	4.74	B220	2.63	11.74	4.20	B260	2.91	12.16	4.74
B261	2.71	13.74	4.57	B221	2.56	12.49	4.09	B261	2.71	13.74	4.57
B262	2.60	13.78	4.38	B222	2.45	11.98	3.87	B262	2.60	13.78	4.38
B263	2.48	13.82	4.11	B223	2.33	12.45	3.67	B263	2.48	13.82	4.11
B264	2.44	15.22	4.11	B224	2.60	11.81	4.11	B264	2.44	15.22	4.11
B265	2.52	13.83	4.36	B225	2.45	12.27	3.99	B265	2.52	13.83	4.36
B266	2.65	13.83	4.36	B226	2.51	12.21	3.99	B266	2.65	13.83	4.36
B267	2.46	12.41	4.10	B227	2.60	12.43	4.11	B267	2.46	12.41	4.10
B268	2.48	11.81	4.31	B228	2.68	11.62	4.14	B268	2.48	11.81	4.31
B269	2.41	13.60	4.39	B229	2.77	12.63	4.31	B269	2.41	13.60	4.39
B270	2.52	14.47	4.07	B230	2.72	12.86	4.22	B270	2.52	14.47	4.07
B271	2.42	13.96	3.93	B231	2.51	13.49	4.66	B271	2.42	13.96	3.93
B272	2.38	15.45	3.65	B232	2.79	11.50	4.39	B272	2.38	15.45	3.65
B273	2.25	13.82	3.80	B233	2.15	19.16	5.01	B273	2.25	13.82	3.80
B274	2.25	15.27	4.24	B234	2.91	9.31	4.42	B274	2.25	15.27	4.24
B275	2.50	15.01	4.66	B235	3.01	10.33	4.63	B275	2.50	15.01	4.66
B276	2.68	11.62	4.14	B236	3.62	10.91	4.64	B276	2.68	11.62	4.14
B277	2.68	11.62	4.14	B237	2.99	19.50	4.62	B277	2.68	11.62	4.14
B278	2.48	13.82	3.80	B238	2.98	10.24	4.60	B278	2.48	13.82	3.80
B279	2.50	15.27	4.24	B239	2.93	10.54	4.60	B279	2.50	15.27	4.24
B280	2.50	15.27	4.24	B240	2.99	13.33	4.80	B280	2.50	15.27	4.24
B281	2.50	15.27	4.24					B281	2.50	15.27	4.24
B282	2.50	15.27	4.24					B282	2.50	15.27	4.24
B283	2.50	15.27	4.24					B283	2.50	15.27	4.24
B284	2.50	15.27	4.24					B284	2.50	15.27	4.24
B285	2.50	15.27	4.24					B285	2.50	15.27	4.24
B286	2.50	15.27	4.24					B286	2.50	15.27	4.24
B287	2.50	15.27	4.24					B287	2.50	15.27	4.24
B288	2.50	15.27	4.24					B288	2.50	15.27	4.24
B289	2.50	15.27	4.24					B289	2.50	15.27	4.24
B290	2.50	15.27	4.24					B290	2.50	15.27	4.24
B291	2.50	15.27	4.24					B291	2.50	15.27	4.24
B292	2.50	15.27	4.24					B292	2.50	15.27	4.24
B293	2.50	15.27	4.24					B293	2.50	15.27	4.24
B294	2.50	15.27	4.24					B294	2.50	15.27	4.24
B295	2.50	15.27	4.24					B295	2.50	15.27	4.24
B296	2.50	15.27	4.24					B296	2.50	15.27	4.24
B297	2.50	15.27	4.24					B297	2.50	15.27	4.24
B298	2.50	15.27	4.24					B298	2.50	15.27	4.24
B299	2.50	15.27	4.24					B299	2.50	15.27	4.24
B300	2.50	15.27	4.24					B300	2.50	15.27	4.24
B301	2.50	15.27	4.24					B301	2.50	15.27	4.24
B302	2.50	15.27	4.24					B302	2.50	15.27	4.24
B303	2.50	15.27	4.24					B303	2.50	15.27	4.24
B304	2.50	15.27	4.24					B304	2.50	15.27	4.24
B305	2.50	15.27	4.24					B305	2.50	15.27	4.24
B306	2.50	15.27	4.24					B306	2.50	15.27	4.24
B307	2.50	15.27	4.24					B307	2.50	15.27	4.24
B308	2.50	15.27	4.24					B308	2.50	15.27	4.24
B309	2.50	15.27	4.24					B309	2.50	15.27	4.24
B310	2.50	15.27	4.24					B310	2.50	15.27	4.24
B311	2.50	15.27	4.24					B311	2.50	15.27	4.24
B312	2.50	15.27	4.24					B312	2.50	15.27	4.24
B313	2.50	15.27	4.24					B313	2.50	15.27	4.24
B314	2.50	15.27	4.24					B314	2.50	15.27	4.24
B315	2.50	15.27	4.24					B315	2.50	15.27	4.24
B316	2.50	15.27	4.24					B316	2.50	15.27	4.24
B317	2.50	15.27	4.24					B317	2.50	15.27	4.24
B318	2.50	15.27	4.24					B318	2.50	15.27	4.24
B319	2.50	15.27	4.24					B319	2.50	15.27	4.24
B320	2.50	15.27	4.24					B320	2.50	15.27	4.24
B321	2.50	15.27	4.24					B321	2.50	15.27	4.24
B322	2.50	15.27	4.24					B322	2.50	15.27	4.24
B323	2.50	15.27	4.24					B323	2.50	15.27	4.24
B324	2.50	15.27	4.24					B324	2.50	15.27	4.24
B325	2.50	15.27	4.24					B325	2.50	15.27	4.24
B326	2.50	15.27	4.24					B326	2.50	15.27	4.24
B327	2.50	15.27	4.24					B327	2.50	15.27	4.24
B328	2.50	15.27	4.24					B328	2.50	15.27	4.24
B329	2.50	15.27	4.24					B329	2.50	15.27	4.24
B330	2.50	15.27	4.24					B330	2.50	15.27	4.24
B331	2.50	15.27	4.24					B331	2.50	15.27	4.24
B332	2.50	15.27	4.24					B332	2.50	15.27	4.24
B333	2.50	15.27	4.24					B333	2.50	15.27	4.24
B334	2.50	15.27	4.24					B334	2.50	15.27	4.24
B335	2.50	15.27	4.24					B335	2.50	15.27	4.24
B336	2.50	15.27	4.24					B336	2.50	15.27	4.24
B337	2.50	15.27	4.24					B337	2.50	15.27	4.24
B338	2.50	15.27	4.24					B338	2.50	15.27	4.24
B339	2.50	15.27	4.24					B339	2.50	15.27	4.24
B340	2.50	15.27	4.24					B340	2.50	15.27	4.24
B341	2.50	15.27	4.24					B341	2.50	15.27	4.24
B342	2.50	15.27	4.24					B342	2.50	15.27	4.24
B343	2.50	15.27	4.24					B343	2.50	15.27	4.24
B344	2.50	15.27	4.24					B344	2.50	15.27	4.24
B345	2.50	15.27	4.24					B345	2.50	15.27	4.24
B346	2.50	15.27	4.24					B346	2.50	15.27	4.24
B347	2.50	15.27	4.24					B347	2.50	15.27	4.24
B348	2.50	15.27	4.24					B348	2.50	15.27	4.24
B349	2.50	15.27	4.24					B349	2.50	15.27	4.24
B350	2.50	15.27	4.24					B350	2.50	15.27	4.24
B351	2.50	15.27	4.24					B351	2.50	15.27	4.24
B352	2.50	15.27	4.24					B352	2.50	15.27	4.24
B353	2.50	15.27	4.24					B353	2.50	15.27	4.24
B354	2.50	15.27	4.24					B354	2.50	15.27	4.24
B355	2.50	15.27	4.24					B355	2.50	15.27	4.24
B356	2.50	15.27	4.24					B356	2.50	15.27	4.24
B357	2.50	15.27	4.24					B357	2.50	15.27	4.24
B358	2.50	15.27	4.24					B358	2.50	15.27	4.24
B359	2.50	15.27	4.24					B359	2.50	15.27	4.24
B360	2.50	15.27	4.24					B360	2.50	15.27	4.24
B361	2.50	15.27	4.24					B361	2.50	15.27	4.24
B362	2.50	15.27	4.24					B362	2.50	15.27	4.24
B363	2.50	15.27	4.24					B363	2.50	15.27	4.24
B364	2.50	15.27	4.24					B364	2.50	15.27	4.24
B365	2.50	15.27	4.24					B365	2.50	15.27</	

with sample values given on a dry basis. The ROM coal set contains 63 points, and the clean coal set has 80 points. Figure 9-2 is a plot of emission rate versus production time for ROM coal and clean coal.

Republic Steel Hourly Data--

For the ROM coal short data strings near the beginning (sample codes 21301 through 21303) and near the end (sample codes 35309 through 39315) were omitted. Missing data were replaced by local averages for sample codes 22313, 24307, 24309, 27315, 30303, 30307, 30313, and 33309.

For the clean coal data, the short data string near the beginning (sample codes 21409 through 22413) of the data set was omitted. Sample values of 27415 were replaced by local averages.

The data set actually used in the time series are displayed in Table 9-3. The sample values are given on dry basis. The ROM coal data have 99 points and the clean coal data have 122 points. Figure 9-3 is a plot of emission rate versus production time both for ROM coal and clean coal.

STATISTICAL ANALYSIS OF EXPERIMENTAL DATA

Before a time series can be analyzed and an optimum model built, the following three preparatory tasks must be performed:

- Estimate the basic statistical parameters of the modified data set.
- Perform a normality check using Kolmogorov-Smirnov one-sample test.
- Calculate the autocorrelation and partial autocorrelation of a stationary time series

Basic Statistical Parameter

The basic statistical parameters estimated include arithmetic mean $\bar{x}$, variance S^2 , third central moment M_3 , and fourth central moment M_4 . The arithmetic mean and variance have been defined previously. The third and fourth central moments for discrete distributions are defined as follows:

$$M_3 = \frac{1}{N} \sum_{i=1}^N (x_i - \bar{x})^3$$

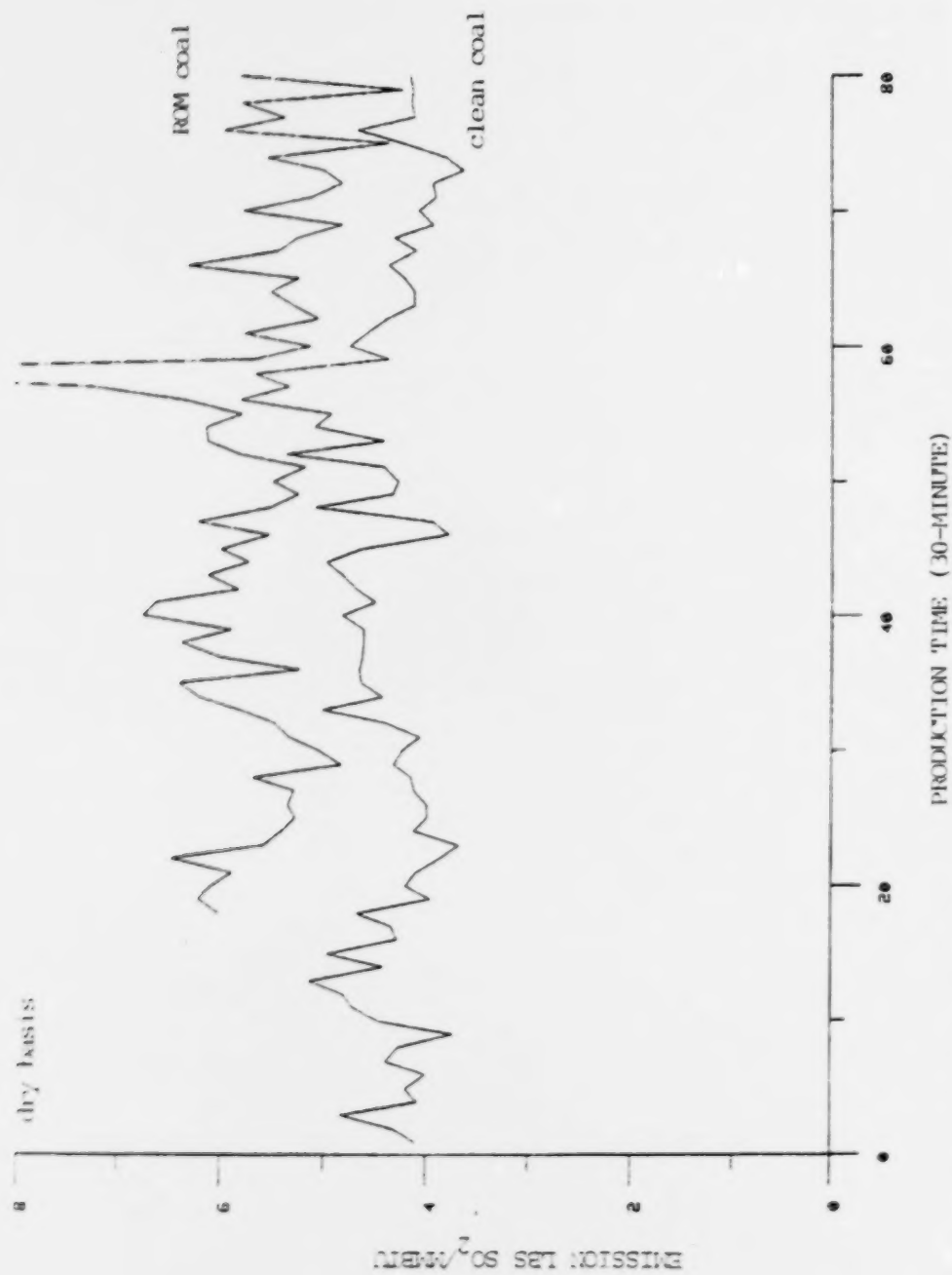


Figure 9-2. R&F Coal Company - 40-hour increment study, emission rate and ROM coal and clean coal. Time series analysis.

TABLE 9-3. DATA USED IN TIME SERIES ANALYSIS-REPUBLIC STEEL CORPORATION HOURLY INCREMENT DATA, ROM COAL AND CLEAN COAL. (DRY BASIS)

ROM COAL, HOURLY DATA, REPUBLIC STEEL					ROM COAL, HOURLY DATA, REPUBLIC STEEL				
CODE	TS	ASH	S02	CODE	TS	ASH	S02	CODE	TS
213 5	2.72	30.82	5.25	283 9	2.12	36.74	5.02	214 1	1.31
213 7	2.26	35.45	4.70	28311	2.75	35.57	5.84	214 3	1.46
213 9	2.28	34.19	4.71	28313	2.45	34.49	5.06	214 5	1.35
21311	2.21	28.27	4.06	28315	2.60	31.38	5.06	214 7	1.44
223 1	2.55	31.22	5.04	293 1	2.81	27.83	5.30	224 1	1.35
223 3	2.41	31.50	4.72	293 3	2.96	26.20	5.45	224 3	1.35
223 5	2.41	35.36	5.03	293 5	2.44	31.49	4.92	224 5	1.41
223 7	2.24	27.70	4.13	293 7	2.45	28.73	6.69	224 7	1.27
223 9	2.60	26.84	4.74	293 9	2.99	28.02	4.43	224 9	1.33
22311	2.45	30.40	4.71	29311	2.99	35.44	6.30	224 11	1.33
22313	2.71	28.77	5.01	29313	2.99	35.44	6.30	224 13	1.33
233 1	2.76	30.08	5.06	29315	3.13	31.06	6.10	224 15	1.30
233 3	3.03	27.76	5.56	303 1	2.52	35.48	5.20	224 17	1.29
233 5	2.55	24.93	4.57	R303 3	2.71	31.75	5.33	224 19	1.35
233 7	2.70	30.47	5.20	303 5	2.74	26.67	5.07	224 21	1.33
233 9	2.44	32.28	4.83	R303 7	2.45	35.79	4.87	224 23	1.33
23311	2.72	40.72	6.20	303 9	1.49	46.38	2.90	224 25	1.33
23313	2.87	26.59	5.21	30311	2.86	37.87	6.34	224 27	1.30
243 1	2.89	37.21	5.48	R30313	2.51	34.36	4.92	224 29	1.30
243 3	3.01	26.85	5.48	313 1	2.83	24.10	4.92	224 31	1.35
243 5	3.03	33.94	6.22	313 3	2.83	29.08	5.34	224 33	1.29
R243 7	2.60	36.82	5.55	313 5	2.69	31.02	5.51	224 35	1.35
R243 9	2.39	39.44	5.33	313 7	2.74	27.99	5.08	224 37	1.36
24311	1.93	47.83	5.61	313 9	2.78	32.47	5.60	224 39	1.47
253 1	2.21	38.98	4.85	31311	2.79	26.26	5.08	224 41	1.25
253 3	2.51	28.01	4.69	323 1	2.90	31.31	5.67	224 43	1.38
253 5	2.77	28.65	5.15	323 3	2.94	31.60	4.62	224 45	1.38
253 7	2.62	38.10	5.81	323 5	3.06	36.54	6.50	224 47	1.38
253 9	2.46	36.46	5.26	323 7	2.79	30.20	5.33	224 49	1.36
25311	2.80	25.22	4.97	323 9	2.27	37.22	4.90	224 51	1.44
25313	2.62	24.52	4.63	32311	2.79	33.59	5.60	224 53	1.45
263 1	2.76	27.64	5.08	32313	2.73	27.02	5.01	R27415	1.30
263 3	2.11	28.78	6.04	333 1	3.52	24.33	4.41	284 1	1.46
263 5	2.12	28.02	5.80	333 3	3.06	31.49	5.96	284 3	1.23
263 7	2.36	36.22	4.92	333 5	2.60	30.40	4.95	284 5	1.22
263 9	2.57	33.76	5.19	333 7	2.48	31.95	4.84	284 7	1.27
26311	2.42	31.57	4.65	R333 9	2.41	29.88	4.61	284 9	1.38
273 1	2.76	28.34	5.13	33311	2.29	28.04	4.20	284 11	1.33
273 3	2.71	37.94	5.91	33313	2.31	29.12	4.48	284 13	1.30
273 5	2.19	37.94	4.74	33315	2.12	37.25	4.58	284 15	1.37
273 7	2.61	39.49	5.83	343 1	2.59	35.02	5.46	284 17	1.41
273 9	2.65	41.40	6.35	343 3	2.69	28.62	4.97	284 19	1.27
27311	2.54	29.01	4.76	343 5	2.69	28.62	5.03	284 21	1.32
27313	2.53	34.15	5.20	343 7	2.97	26.96	5.59	284 23	1.26
R27315	2.47	32.16	4.82	343 9	2.60	36.46	5.47	284 25	1.31
283 1	2.07	34.83	4.23	34311	2.75	33.58	5.47	284 27	1.35
283 3	2.59	30.63	4.90	34313	2.70	29.73	5.18	284 29	1.35
283 5	2.90	26.88	5.30	353 1	2.85	28.93	5.38	284 31	1.35
283 7	2.25	32.95	4.54	353 3	2.73	30.72	5.20	284 33	1.35
283 9	2.25	32.95	4.54	353 5	2.73	30.72	5.20	284 35	1.35
28311	2.25	32.95	4.54	353 7	2.73	30.72	5.20	284 37	1.35
28313	2.25	32.95	4.54	353 9	2.73	30.72	5.20	284 39	1.35
28315	2.25	32.95	4.54	35311	2.73	30.72	5.20	284 41	1.35
28313	2.25	32.95	4.54	35313	2.73	30.72	5.20	284 43	1.35
28315	2.25	32.95	4.54	35315	2.73	30.72	5.20	284 45	1.35
28317	2.25	32.95	4.54	35317	2.73	30.72	5.20	284 47	1.35
28319	2.25	32.95	4.54	35319	2.73	30.72	5.20	284 49	1.35
28321	2.25	32.95	4.54	35321	2.73	30.72	5.20	284 51	1.35
28323	2.25	32.95	4.54	35323	2.73	30.72	5.20	284 53	1.35
28325	2.25	32.95	4.54	35325	2.73	30.72	5.20	284 55	1.35
28327	2.25	32.95	4.54	35327	2.73	30.72	5.20	284 57	1.35
28329	2.25	32.95	4.54	35329	2.73	30.72	5.20	284 59	1.35
28331	2.25	32.95	4.54	35331	2.73	30.72	5.20	284 61	1.35
28333	2.25	32.95	4.54	35333	2.73	30.72	5.20	284 63	1.35
28335	2.25	32.95	4.54	35335	2.73	30.72	5.20	284 65	1.35
28337	2.25	32.95	4.54	35337	2.73	30.72	5.20	284 67	1.35
28339	2.25	32.95	4.54	35339	2.73	30.72	5.20	284 69	1.35
28341	2.25	32.95	4.54	35341	2.73	30.72	5.20	284 71	1.35
28343	2.25	32.95	4.54	35343	2.73	30.72	5.20	284 73	1.35
28345	2.25	32.95	4.54	35345	2.73	30.72	5.20	284 75	1.35
28347	2.25	32.95	4.54	35347	2.73	30.72	5.20	284 77	1.35
28349	2.25	32.95	4.54	35349	2.73	30.72	5.20	284 79	1.35
28351	2.25	32.95	4.54	35351	2.73	30.72	5.20	284 81	1.35
28353	2.25	32.95	4.54	35353	2.73	30.72	5.20	284 83	1.35
28355	2.25	32.95	4.54	35355	2.73	30.72	5.20	284 85	1.35
28357	2.25	32.95	4.54	35357	2.73	30.72	5.20	284 87	1.35
28359	2.25	32.95	4.54	35359	2.73	30.72	5.20	284 89	1.35
28361	2.25	32.95	4.54	35361	2.73	30.72	5.20	284 91	1.35
28363	2.25	32.95	4.54	35363	2.73	30.72	5.20	284 93	1.35
28365	2.25	32.95	4.54	35365	2.73	30.72	5.20	284 95	1.35
28367	2.25	32.95	4.54	35367	2.73	30.72	5.20	284 97	1.35
28369	2.25	32.95	4.54	35369	2.73	30.72	5.20	284 99	1.35
28371	2.25	32.95	4.54	35371	2.73	30.72	5.20	284 101	1.35
28373	2.25	32.95	4.54	35373	2.73	30.72	5.20	284 103	1.35
28375	2.25	32.95	4.54	35375	2.73	30.72	5.20	284 105	1.35
28377	2.25	32.95	4.54	35377	2.73	30.72	5.20	284 107	1.35
28379	2.25	32.95	4.54	35379	2.73	30.72	5.20	284 109	1.35
28381	2.25	32.95	4.54	35381	2.73	30.72	5.20	284 111	1.35
28383	2.25	32.95	4.54	35383	2.73	30.72	5.20	284 113	1.35
28385	2.25	32.95	4.54	35385	2.73	30.72	5.20	284 115	1.35
28387	2.25	32.95	4.54	35387	2.73	30.72	5.20	284 117	1.35
28389	2.25	32.95	4.54	35389	2.73	30.72	5.20	284 119	1.35
28391	2.25	32.95	4.54	35391	2.73	30.72	5.20	284 121	1.35
28393	2.25	32.95	4.54	35393	2.73	30.72	5.20	284 123	1.35
28395	2.25	32.95	4.54	35395	2.73	30.72	5.20	284 125	1.35
28397	2.25	32.95	4.54	35397	2.73	30.72	5.20	284 127	1.35
28399	2.25	32.95	4.54	35399	2.73	30.72	5.20	284 129	1.35
28401	2.25	32.95	4.54	35401	2.73	30.72	5.20	284 131	1.35
28403	2.25	32.95	4.54	35403	2.73	30.72	5.20	284 133	1.35
28405	2.25	32.95	4.54	35405	2.73	30.72	5.20	284 135	1.35
28407	2.25	32.95	4.54	35407	2.73	30.72	5.20	284 137	1.35
28409	2.25	32.95	4.54	35409	2.73	30.72	5.20	284 139	1.35
28411	2.25	32.95	4.54	35411	2.73	30.72	5.20	284 141	1.35
28413	2.25	32.95	4.54	35413	2.73	30.72	5.20	284 143	1.35
28415	2.25	32.95	4.54	35415	2.73	30.72	5.20	284 145	1.35
28417	2.25	32.95	4.54	35417	2.73	30.72	5.20	284 147	1.35
28419	2.25	32.95	4.54	35419	2.73	30.72	5.20	284 149	1.35
28421	2.25	32.95	4.54	35421	2.73	30.72	5.20	284 151	1.35
28423	2.25	32.95	4.54	35423	2.73	30.72	5.20	284 153	1.35
28425	2.25	32.95	4.54	35425	2.73	30.72	5.20	284 155	1.35
28427	2.25	32.95	4.54	35427	2.73	30.72	5.20	284 157	1.35
28429	2.25	32.95	4.54	35429	2.73	30.72	5.20	284 159	1.35
28431	2.25	32.95	4.54	35431	2.73	30.72	5.20	284 161	1.35
28433	2.25	32.95	4.54	35433	2.73	30.72	5.20	284 163	1.35
28435	2.25	32.95	4.54	35435	2.73	30.72	5.20	284 165	1.35
28437	2.25	32.95	4.54	35437	2.73	30.72	5.20	284 167	1.35
28439	2.25	32.95	4.54	35439	2.73	30.72	5.20	284 169	1.35
28441	2.25	32.95	4.54	35441	2.73	30.72	5.20	284 171	1.35
28443	2.25	32.9							

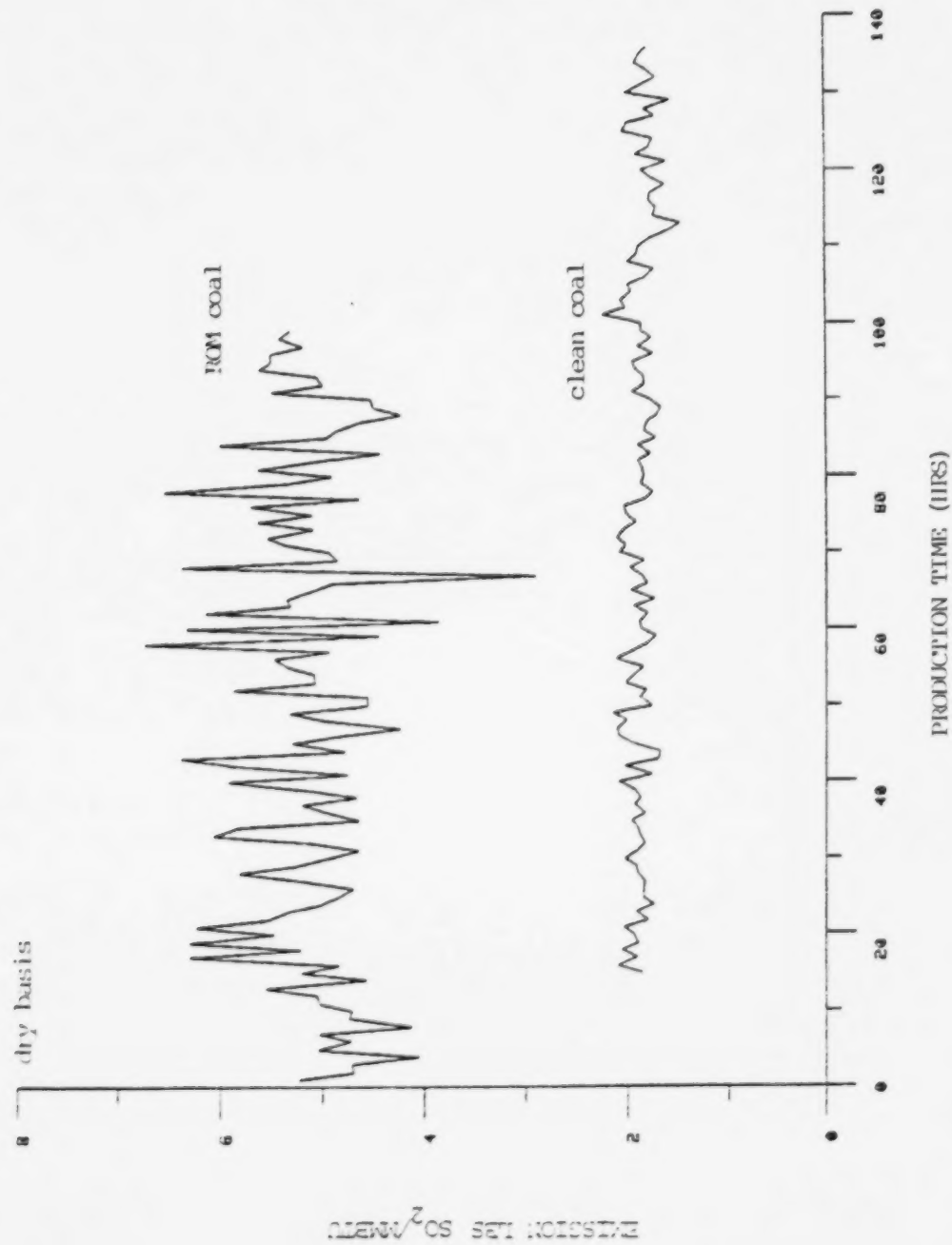


Figure 9-3. Republic Steel Corporation - hourly data, emission rate for ROM coal and clean coal.

$$M_4 = \frac{1}{N} \sum_{i=1}^N (x_i - \bar{x})^4$$

The M_3 value is related to the symmetry of the distribution. For example, a distribution has positive skewness if M_3 is positive. This means that the arithmetic mean is biased by values higher than the mean and the distribution has a long tail to the right, (i.e., the right tail is longer than the left tail). In practice, it is normal to calculate the coefficient of skewness a_3 which is a dimensionless parameter defined as

$$a_3 = \frac{M_3}{(S^2)^{3/2}}$$

The M_4 value describes the distribution at the tails. A large M_4 value implies the data are concentrated in the tails of the distribution. Usually M_4 is used to define the kurtosis (a_4) of the distribution, where

$$a_4 = \frac{M_4}{(S^2)^2}$$

For a Gaussian distribution, $a_4=3$. Thus a measure of the deviation from the Gaussian distribution at the tails is (a_4-3) , which is known as the coefficient of excess.

The calculations of $\bar{x}$, s^2 , a_3 , and (a_4-3) for three data sets are given in Table 9-4.

Normality Check Using Kolmogorov-Smirnov One-sample Test

The Kolmogorov-Smirnov one-sample test is a procedure to test the hypothesis of equality of any given sample distribution and any theoretical distribution (in this case, a Gaussian distribution), allowing consideration of one or two sided alternatives. The basic idea is to calculate the ordinate of the cumulative distribution function both for the sample distribution and a theoretical Gaussian distribution (a complementary error function with the same mean and variance). The comparison is carried out by the subroutine NKS1 in IMSL, which subsequently calculates the asymptotic

TABLE 9-4 BASIC STATISTICAL PARAMETERS

	ROM COAL					CLEAN COAL				
	Nb. of Samples	$\bar{x}$ Mean	S^2 Total Variance	a_3 Coeff. of Skewness	$(a_3 - 3)$ Coeff. of Excess	Nb. of Samples	$\bar{x}$ Mean	S^2 Total Variance	a_3 Coeff. of Skewness	$(a_3 - 3)$ Coeff. of Excess
RAF (22 Hour) Sample Code A	44					43				
Total Sulfur %		2.82	0.0453	-0.1127	-0.5531		2.39	0.0108	0.0068	-0.6371
Ash %		20.59	4.8267	-1.1277	0.2689		14.08	0.8498	-0.3063	-0.3524
Emulsion rate (lb SO ₂ /MMBtu)		5.07	0.1627	-0.0941	0.4980		3.93	0.0202	0.6031	1.5973
RAF (40 Hour) Sample Code B & C	63					80				
Total Sulfur %		3.22	0.1421	0.7763	2.1938		2.73	0.0803	0.7431	0.0172
Ash %		19.80	7.275	-0.1722	-0.5343		12.09	4.703	-0.5746	-0.1784
Emulsion rate (lb SO ₂ /MMBtu)		5.74	0.8087	3.6485	20.6017		4.39	0.1957	0.8966	0.7539
Republic Steel Hourly Data	99					122				
Total Sulfur %		2.60	0.0814	-0.5785	1.1484		1.30	0.0070	-0.1309	0.2101
Ash %		32.23	24.48	0.9442	1.1405		9.30	0.5253	0.7374	1.7541
Emulsion rate (lb SO ₂ /MMBtu)		5.15	0.3735	-0.0400	1.2295		1.87	0.0168	-0.0471	0.2590

probabilities of equality $P(\text{one and two-sided})$ for sample sizes greater than 80. If $P(\text{two-sided})$ exceeds typical significance levels (0.05, 0.10, etc.), one would not reject the hypothesis of equality.

Table 9-5 summarizes the results of this calculation both for the original data sets before autocorrelation is taken out, and for the residues after autocorrelation is removed. Table 9-5 shows that the probability of being a normal distribution is much higher for the residues than for the original data.

Calculation of Autocorrelation and Partial Autocorrelation of a Stationary Time Series

Given a stationary time series with arithmetic mean $\bar{x}$ and variance s^2 , one can calculate the covariance at lag j as follows:

$$c_j = \frac{1}{N} \sum_{i=1}^{n-j} (x_i - \bar{x})(x_{i+j} - \bar{x})$$

This value is defined as the autocovariance at lag j . It is more useful to estimate the autocorrelation, which is a dimensionless parameter

$$r_j = \frac{c_j}{s^2}$$

The autocorrelation function, r_j , reveals the correlation between any two values of the series as their separation changes. In the past, the autocorrelation function has sometimes been called the correlogram.

The partial autocorrelation function ϕ_{kk} , is a parameter that helps to define the order of the autoregressive process for an observed time series. For an autoregressive process of order p , the autocorrelation function ϕ_{kk} will be nonzero for k less than or equal to p and zero for k greater than p . In other words, the partial autocorrelation function of a p^{th} order autoregressive process is zero after lag p .

The estimation of the partial autocorrelation function ϕ_{kk} can be handled by the Durbin recursive formulas,⁽⁸⁾ and is calculated by the subroutine FTAUTO in IMSL.

TABLE 9-5 NORMALITY CHECK USING KOLMOGOROV-SMIRNOV ONE SAMPLE TEST

	No. of Samples	ROM			COAL			CLEAN			COAL		
		P(one-sided)		No. of Samples	P(two-sided)		No. of Samples	P(one-sided)		No. of Samples	P(two-sided)		No. of Samples
		Original Data	Residues		Original Data	Residues		Original Data	Residues		Original Data	Residues	
RAF (22 Hour) Sample Code A	44*												
Total sulfur %		0.5652	0.6419		0.9378	0.9796		0.3016	0.3363		0.5866	0.6471	
Ash %		0.0180	0.5199		0.0359	0.8991		0.5307	0.6117		0.9094	0.9666	
Emission rate (lb SO ₂ /MMBtu)		0.5792	0.5092		0.9476	0.8885		0.3453	0.5510		0.6623	0.9269	
RAF (40 Hour) Sample Code B&C	63*												
Total sulfur %		0.3704	0.4249		0.7034	0.7055		0.1325	0.4585		0.2643	0.8303	
Ash %		0.4397	0.1524		0.8059	0.3037		0.2806	0.3477		0.5488	0.6663	
Emission rate (lb SO ₂ /MMBtu)		0.0400	0.0453		0.0800	0.0905		0.0723	0.3679		0.1445	0.6994	
Bradford Steel Plant Data	99												
Total sulfur %		0.3606	0.5679		0.6876	0.9346		0.4584	0.3826		0.8303	0.7227	
Ash %		0.1079	0.3100		0.2155	0.6016		0.1982	0.4159		0.3933	0.7726	
Emission rate (lb SO ₂ /MMBtu)		0.2611	0.6419		0.5130	0.9796		0.5913	0.5855		0.9553	0.9517	

*FEDER TION 80 SAMPLE POINTS

Table 9-6 presents the results of the autocorrelation function and partial autocorrelation function both for the original data before autocorrelation is taken out and for the residues after the autocorrelation is taken out. From past experience, autocorrelation and partial correlation are considered to be insignificant if their numerical values are less than $2/\sqrt{N}$, where N is the number of data points.

Table 9-6 shows that the residues are less correlated than the original data.

Model Building Using ARIMA (Box-Jenkins) Process

The purpose of this Section is to determine the order (p, q) of an ARIMA process in fitting a time series to the experimental data. From a visual inspection of the original data, little or no trending was detected, and we consider stationary time series only. Thus the following discussion is limited to mixed autoregressive - moving average models.

The initial guess of (p, q) values was determined by an inspection of the autocorrelation and partial correlation. In many cases, the (1, 1) model was picked as the starting point. The autoregressive parameters and moving-average parameters were estimated by the maximum likelihood method, which minimizes the white noise variance through parameter iteration.

$$WNV = \sum_{t=1}^N a_t^2$$

where a_t is the residue or random shock,
and $a_t = 0.0$ for $t = 1, \dots, \max(p, q)$.

After parameter iteration was completed, the residues were printed out for further diagnostic checks of normality and autocorrelation. This calculation was handled by subroutine FTMXL in IMSL.

After the maximum likelihood estimates of parameters, it was noticed that some of the estimates of autoregressive and moving-average parameters were small (less than 0.10). It is expected that the influences of these parameters may be negligibly small. However, the present version of IMSL subroutines do not allow the freedom to throw out terms associated with

TABLE 9-6 CORRELATION STRUCTURE OF ROM COAL AND CLEAN COAL BEFORE AND AFTER
AUTOCORRELATION STRUCTURE IS REMOVED
30-MINUTE INCREMENT DATA (40-HOUR STUDY) FOR SULFUR DIOXIDE EMISSION RATE

Time Lag	ROM COAL			CLEAN COAL		
	Autocorrelation Original Data	Autocorrelation Residuals	Partial Autocorrelation Original Data	Autocorrelation Original Data	Autocorrelation Residuals	Partial Autocorrelation Residuals
1	0.2840	-0.0185	0.2840	0.5105	-0.0137	-0.0137
2	0.1338	0.0413	0.0578	0.4534	-0.0553	-0.0555
3	0.0855	0.0377	0.0363	0.3356	-0.0169	-0.0186
4	0.0689	0.0522	0.0322	0.3795	0.2659	0.2632
5	-0.0056	-0.0275	-0.0444	0.1741	-0.0051	-0.0002
6	0.0066	0.0420	0.0098	0.3704	-0.0963	-0.0767
7	-0.1013	-0.1148	-0.1152	-0.0305	-0.1242	-0.1279
8	-0.0137	0.0537	0.0455	0.359	0.1129	0.0371
9	-0.1196	-0.1141	-0.1202	-0.1016	-0.0549	-0.0653
10	-0.0661	-0.0076	0.0027	-0.0820	0.0264	0.0814
11	-0.1084	-0.0949	-0.0732	-0.2073	-0.1857	-0.1395
12	-0.0211	0.0223	0.0386	-0.1084	0.0483	0.0060
13	-0.0354	0.0011	-0.0111	-0.1435	-0.0595	-0.0718
14	-0.1119	-0.0992	-0.1220	-0.1162	-0.0135	-0.0378
15	-0.0658	-0.0390	0.0160	-0.0864	0.0389	0.1347
16	-0.0119	0.0162	-0.0131	-0.1102	-0.0563	-0.0906
17	-0.0390	-0.0773	-0.0125	-0.1396	-0.1322	-0.1190
18	0.1051	0.1284	0.1178	-0.0219	0.0734	0.0401
19	0.0384	-0.0150	-0.0182	-0.0403	0.0151	-0.0101
20	0.0829	0.1228	0.0593	-0.0128	0.0215	0.0287
21	-0.1280	-0.1519	-0.2311	-0.0430	-0.0660	0.0078
22	-0.0775	-0.0826	-0.0075	-0.0107	-0.0015	-0.0751
23	0.0822	0.1056	0.1319	0.0109	0.0571	0.0169
24	0.0461	0.0381	-0.0201	-0.0010	0.0475	0.0288

small parameters. As a result, a sensitivity analysis was performed on the parameter estimates determined by the maximum likelihood method (e.g., setting the small parameter estimates to zero and perturbing the large parameter estimates). The objective was to see if the influence associated with small parameters is indeed small. If the white noise variance remained small, then it would be possible to arrive at a simpler but reasonable model for a given parameter by ignoring the terms with little significance.

Table 9-7 summarizes the parametric estimates of the ARIMA models. The R&F 40-hour increments study data can be fitted by autoregressive models AR(1) or AR(2). In these models a sample value (i.e., sulfur, ash or emission parameter) is dependent only on the previous sample value -- here, the last half-hour and last hour value. The emission model AR(1) for raw coal marginally passed the normality check and is probably an underfit of data, while the alternate emission model using log transformed data is probably an overfit of data. The Republic Steel hourly data can also be fitted by an autoregressive model as shown in Table 9-7. The rest of the data can be fitted by higher order autoregressive models, moving average models, and mixed autoregressive-moving average models.

Table 9-8 is a comparison of total variance, white noise variance, and analysis variance. The factor $R^2 = (1 - \frac{WNV}{S^2})$ represents the percentage of variance that can be explained, based on past data points. The remainder of the variance is attributed to randomness that cannot be identified or explained by this analysis. The values of R^2 range from 0.098 to 0.776 in Table 9-8. The analysis variance for ash and sulfur is a measure of the capability to duplicate sample values.

Prediction of Emission Limit Violation by Time Series Generation

The fitted ARIMA model can be used directly to generate time series by simple recursive calculations. This calculation can be handled by the subroutine FTGEN in IMSL. The R&F 40-hour increment data demonstrates the capability of time series to predict the emission rates. The time series generation will be limited to an AR(2) model, that contains an AR(1) model as a degenerate case ($\phi_2 = 0$).

TABLE 9-7. PARAMETERS IN ARIMA (BOX-JENKINS) MODEL

	ROM COAL					REMARKS	CLEAN COAL					
	P	d	q	CMAC	WMA		P	d	q	CMAC	WMA	
Ref Sample Oxide A (22 hour)												
Total Sulfur	1	0	3	1.0565	0.0216	$\phi_1 = 0.6256, \theta_1 = -0.3, \text{ other parameters } 0$	0	0	3	2.3007	0.0065	$\theta_2 = -0.32, \theta_3 = -0.50$
Ash	3	0	0	4.9398	1.0836	$\phi_1 = 0.7809, \theta_2 = -0.1836, \phi_3 = 0.2120$	1	0	0	3.3104	0.3172	$\phi_1 = 0.7649$
Emission rate	1	0	0	1.7812	0.0855	$\phi_1 = 0.6409$	0	0	4	3.9267	0.0191	$\theta_1 = -0.5225, \theta_2 = -0.5446, \text{ other parameters } 0$
Alternate Emission Model	5	0	0	2.2181	0.0732	$\phi_1 = 0.617, \phi_2 = 0, \phi_3 = 0.292, \phi_4 = 0.221, \phi_5 = -0.135$	-	-	-	-	-	-
Ref Sample Oxide BOC (40 hour)												
Total Sulfur	2	0	0	1.3780	0.1031	$\phi_1 = 0.3669, \phi_2 = 0.2052$	2	0	0	0.8317	0.0479	$\phi_1 = 0.3966, \phi_2 = 0.2990$
Ash	2	0	0	5.8540	4.4415	$\phi_1 = 0.3100, \phi_2 = 0.3943$	1	0	0	2.0482	1.2283	$\phi_1 = 0.8303$
Emission rate	1	0	0	4.1077	0.7220	$\phi_1 = 0.2840$	2	0	0	1.5706	0.1288	$\phi_1 = 0.3787, \phi_2 = 0.2642$
Alternate Emission Model (Log-Transformed)	1	0	0	1.1951	0.0154	$\phi_1 = 0.3122$	-	-	-	-	-	-
Republic Steel Hourly Data												
Total Sulfur	5	0	0	2.6588	0.0734	$\phi_1 = 0.14, \phi_2 = -0.16, \text{ other parameters } 0$	2	0	0	0.7272	0.0059	$\phi_1 = 0.2328, \phi_2 = 0.2099$
Ash	0	0	3	32.2309	21.6379	$\theta_1 = -0.2427, \theta_2 = -0.1035, \theta_3 = 0.1969$	1	0	0	4.8856	0.4034	$\phi_1 = 0.4749$
Emission rate	2	0	6	3.46	0.3047	$\phi_1 = 0.25, \theta_2 = -0.35, \text{ other parameters } 0$	2	0	0	1.0156	0.0139	$\phi_1 = 0.2474, \phi_2 = 0.2088$

CMC = Overall moving average constant; MIN = White noise variance

TABLE 9-8
COMPARISON OF TOTAL VARIANCE, WHITE NOISE VARIANCE,
AND ANALYSIS VARIANCE

ROM COAL									
	No. of Samples	$\bar{x}$ Mean	S^2 Total Variance	WNV White Noise Variance	R^2 $\frac{WNV}{S^2}$ $= 1 -$	Analysis Variance	Composite Variance	Co Nugget Constant	
R&F (22 Hour)									
Sample Code A	44								
Total Sulfur %		2.82	0.0453	0.0216	0.523	0.004	0.0224	0.006	
Ash %		20.59	4.8267	1.0836	0.776	0.031	0.964	0.15	
Emission Rate (lb SO ₂ /HHBTU)		5.07	0.1627	0.0855	0.475	N/A	0.0617	0.021	
Alternate Emission Rate		5.07	0.1627	0.0732	0.550	N/A		0.021	
R&F (40 Hour)									
Sample Code B&C	63								
Total Sulfur %		3.22	0.1421	0.1031	0.274	0.003	0.0224	0.109	
Ash %		19.80	7.275	4.4415	0.390	0.034	0.964	1.86	
Emission Rate (lb SO ₂ /HHBTU)		5.74	0.8087	0.7220	0.107	N/A	0.0617	0.400	
Alternate Emission Rate (log transformed data)		1.74	0.0175	0.0154	0.120	N/A	N/A	N/A	
Republic Steel									
Hourly Data	99								
Total Sulfur %		2.60	0.0814	0.0734	0.098	0.005	0.0378	0.077	
Ash %		32.23	24.48	21.6379	0.116	0.065	8.311	12.71	
Emission Rate (lb SO ₂ /HHBTU)		5.15	0.3735	0.3047	0.184	N/A	0.1314	0.37	

TABLE 9-8 (Continued)
COMPARISON OF TOTAL VARIANCE, WHITE NOISE VARIANCE,
AND ANALYSIS VARIANCE

CLEAN COAL									
	No. of Samples	$\bar{x}$ Mean	S^2 Total Variance	WNV White Noise Variance	R^2 $= 1 - \frac{WNV}{S^2}$	Analysis Variance	Composite Variance	Co Nugget Constant	
R&F (22 Hour) Sample Code A	43								
Total Sulfur %		2.39	0.0108	0.0065	0.398	0.004	0.0101	0.0050	
Ash %		14.08	0.8498	0.3372	0.603	0.024	0.638	0.068	
Emission Rate (lb SO ₂ /MMBTU)		3.98	0.0292	0.0191	0.346	N/A	0.0391	0.021	
Alternate Emission Rate									
R&F (40 Hour) Sample Code B&C	80								
Total Sulfur %		2.73	0.0803	0.0479	0.403	0.004	0.0101	0.036	
Ash %		12.09	4.703	1.2283	0.740	0.052	0.638	1.36	
Emission Rate (lb SO ₂ /MMBTU)		4.39	0.1957	0.1288	0.342	N/A	0.0391	0.100	
Alternate Emission Rate (log transformed data)									
Republic Steel Hourly Data	122								
Total Sulfur %		1.30	0.0070	0.0059	0.157	0.0020	0.0040	0.0050	
Ash %		9.30	0.5253	0.4034	0.232	0.031	0.1121	0.15	
Emission Rate (lb SO ₂ /MMBTU)		1.87	0.0168	0.0139	0.173	N/A	0.0081	0.011	

Before a time series generation can be carried out, the mean $\bar{x}$, variance S^2 , and autoregressive parameters ϕ_1 , ϕ_2 must be specified. The overall moving average constant and white noise variance are determined as follows:

$$\theta_0 = \bar{x} (1 - \phi_1 - \phi_2)$$

$$WNV = S^2 \frac{1 + \phi_2}{1 - \phi_2} (1 - \phi_2)^2 - \phi_1^2$$

The equations illustrate how time series generation utilizes past data to determine the variance of the forecast errors, and to calculate confidence limits within which a future value of time series will lie.

The input to the time series is a random number generator. Generally, the AR model smooths out random noise by using an autoregressive filter. The absence of the autoregressive filter produces only an uncorrelated noise. A time series can be generated for intervals of one-half hour by recursive calculations, as long as one does not violate the assumption of constant mean, variance, and correlation structure over the time period. These half-hour data points can be composited mathematically into daily averages to determine how many violations there are in a given year.

Since the ARIMA model is a probability model, the time series generated may or may not visually resemble the original time series based on experimental data. This original time series and the generated time series are simply variants of the same random variable and are equally probable. Thus to determine the number of violations per year on the average, one must generate a large number of time series (e.g., 100 years).

Prediction of the Average Number of Emission Violations

The results of 100 year simulation for ROM coal and clean coal are presented in Table 9-9. The values of mean, variance, ϕ_1 , and ϕ_2 are those listed in Table 9-7. For comparative purposes a reference Gaussian emission limit is set at a value of $(\bar{x} + 2.5\sqrt{S^2/48})$. The factor $S^2/48$ is the estimated sample mean variance for the daily averages based on the

TABLE 9-9 PREDICTION OF AVERAGE NUMBER OF EMISSION VIOLATION PER YEAR BASED ON 24-HOUR AVERAGING TIME FOR ROM COAL AND CLEAN COAL,
USING EMISSION MODEL FOR BAF 40-HOUR INCIDENT STUDY

ROM COAL						CLEAN COAL					
$\bar{x}$ (1/yr) = 5.74, s^2 (1/yr) = 0.8087, violation level* = 6.06						$\bar{x}$ (1/yr) = 4.39, s^2 (1/yr) = 0.1957, violation level* = 4.55					
Uncorrelated data $\phi_1 = 0, \phi_2 = 0$						Uncorrelated data $\phi_1 = 0, \phi_2 = 0$					
N	Yr. with N Violations	(N x M)	N	Yr. with N Violations	(N x M)	N	Yr. with N Violations	(N x M)	N	Yr. with N Violations	(N x M)
0	8	0	2	1	2	0	16	0	33	1	33
1	24	24	4	2	8	1	26	26	38	2	76
2	32	64	5	2	10	2	26	52	39	4	156
3	18	54	6	4	24	3	21	63	41	4	164
4	7	28	7	7	49	4	4	16	42	4	168
5	4	20	8	8	64	5	7	35	43	4	172
6	5	30	9	8	81	6	100	192	44	6	264
7	1	7	10	13	130	7	7	49	45	6	270
8	1	8	11	5	55	8	100	192	46	12	552
9	1	9	12	14	168	9	100	192	47	4	188
TOTAL	106	237	13	7	91	TOTAL	100	192	48	8	384
Average no. of violation/yr = 2.37						Average no. of violation/yr = 1.92					
14	14	196	14	14	196	10	100	192	49	5	245
15	6	90	15	6	90	11	100	192	50	6	300
16	2	32	16	2	32	12	100	192	51	6	306
17	2	34	17	2	34	13	100	192	52	5	260
18	3	54	18	3	54	14	100	192	53	4	212
19	3	57	19	3	57	15	100	192	54	1	54
20	2	42	20	2	42	16	100	192	55	2	110
21	1	21	21	1	21	17	100	192	56	2	112
22	1	22	22	1	22	18	100	192	57	5	285
23	1	23	23	1	23	19	100	192	58	1	58
TOTAL	106	237	TOTAL	100	192	20	100	192	59	5	295
Average no. of violation/yr = 11.69						Average no. of violation/yr = 48.57					
24	1	24	24	1	24	21	100	192	60	2	120
25	1	25	25	1	25	22	100	192	61	2	122
26	1	26	26	1	26	23	100	192	62	2	124
27	1	27	27	1	27	24	100	192	63	1	63
28	1	28	28	1	28	25	100	192	64	1	64
29	1	29	29	1	29	26	100	192	65	1	65
30	1	30	30	1	30	27	100	192	TOTAL	100	4,857
31	1	31	31	1	31	28	100	192	Average no. of violation/yr. = 48.57		
32	1	32	32	1	32	29	100	192			
33	1	33	33	1	33	30	100	192			
34	1	34	34	1	34	31	100	192			
35	1	35	35	1	35	32	100	192			
36	1	36	36	1	36	33	100	192			
37	1	37	37	1	37	34	100	192			
38	1	38	38	1	38	35	100	192			
39	1	39	39	1	39	36	100	192			
40	1	40	40	1	40	37	100	192			
41	1	41	41	1	41	38	100	192			
42	1	42	42	1	42	39	100	192			
43	1	43	43	1	43	40	100	192			
44	1	44	44	1	44	41	100	192			
45	1	45	45	1	45	42	100	192			
46	1	46	46	1	46	43	100	192			
47	1	47	47	1	47	44	100	192			
48	1	48	48	1	48	45	100	192			
49	1	49	49	1	49	46	100	192			
50	1	50	50	1	50	47	100	192			
51	1	51	51	1	51	48	100	192			
52	1	52	52	1	52	49	100	192			
53	1	53	53	1	53	50	100	192			
54	1	54	54	1	54	51	100	192			
55	1	55	55	1	55	52	100	192			
56	1	56	56	1	56	53	100	192			
57	1	57	57	1	57	54	100	192			
58	1	58	58	1	58	55	100	192			
59	1	59	59	1	59	56	100	192			
60	1	60	60	1	60	57	100	192			
61	1	61	61	1	61	58	100	192			
62	1	62	62	1	62	59	100	192			
63	1	63	63	1	63	60	100	192			
64	1	64	64	1	64	61	100	192			
65	1	65	65	1	65	62	100	192			
66	1	66	66	1	66	63	100	192			
67	1	67	67	1	67	64	100	192			
68	1	68	68	1	68	65	100	192			
69	1	69	69	1	69	66	100	192			
70	1	70	70	1	70	67	100	192			
71	1	71	71	1	71	68	100	192			
72	1	72	72	1	72	69	100	192			
73	1	73	73	1	73	70	100	192			
74	1	74	74	1	74	71	100	192			
75	1	75	75	1	75	72	100	192			
76	1	76	76	1	76	73	100	192			
77	1	77	77	1	77	74	100	192			
78	1	78	78	1	78	75	100	192			
79	1	79	79	1	79	76	100	192			
80	1	80	80	1	80	77	100	192			
81	1	81	81	1	81	78	100	192			
82	1	82	82	1	82	79	100	192			
83	1	83	83	1	83	80	100	192			
84	1	84	84	1	84	81	100	192			
85	1	85	85	1	85	82	100	192			
86	1	86	86	1	86	83	100	192			
87	1	87	87	1	87	84	100	192			
88	1	88	88	1	88	85	100	192			
89	1	89	89	1	89	86	100	192			
90	1	90	90	1	90	87	100	192			
91	1	91	91	1	91	88	100	192			
92	1	92	92	1	92	89	100	192			
93	1	93	93	1	93	90	100	192			
94	1	94	94	1	94	91	100	192			
95	1	95	95	1	95	92	100	192			
96	1	96	96	1	96	93	100	192			
97	1	97	97	1	97	94	100	192			
98	1	98	98	1	98	95	100	192			
99	1	99	99	1	99	96	100	192			
100	1	100	100	1	100	97	100	192			

*Violation level is taken as the SIP value and is equal to $(\bar{x} + 2.5s^2/40)$

variance of half-hour points, according to Central Limit Theorem in classical statistics. The factor 2.5 is the value of normal deviates, and implies 99.4 percent compliance time, or equivalently, 2.3 violations per year, assuming independent data.

Table 9-9 shows that for the correlated data the number of violations per year ranges from 33 to 65 for clean coal, and from 2 to 23 for ROM coal. The average number of violations per year can be calculated by summing the total number of violations and dividing by the total number of years simulated. As a result, the clean coal emissions average 49 violations per year, while the ROM coal has an average of 12 violations per year.

Similar calculations for the case of uncorrelated data can be performed to check the prediction of emission violation. This is accomplished simply by setting both ϕ_1 and ϕ_2 to zero. The results are also presented in Table 9-9. It is seen that the number of violations per year ranges from 5 to 0 for clean coal and from 9 to 0 for ROM coal. As expected, the average number of emission violations per year is 2 for both clean coal and for ROM coal.

Thus, the prediction of emission violations is ten times larger for correlated data than for uncorrelated data. In other words, statistics that assumes independent data points grossly underestimates the number of emission violations that occur with correlated phenomena.

Table 9-10 presents the results of a hypothetical case, given hourly mean, hourly variance, and four levels of correlation structure. As expected from the analysis above, the uncorrelated data predict the smallest number of violations, with the average number of violations increasing with the level of correlation structure.

Determination of Cut-off Emission Rate for a Predetermined Compliance Level

A converse to the case study described above is to determine the compliance emission level that produces only two violations per year on the average (cut-off emission rate). This value is developed by constructing histograms of daily average emission rate from 100 year simulation, using time series generation at 30-minute increments.

TABLE 9-10 PREDICTION OF ADVANCE NUMBER OF EMISSION VIOLATION PER YEAR BASED ON 24-HOUR AVERAGE TIME, USING AN AR2 MODEL WITH FOUR HYPOTHETICAL LEVELS OF AUTOCORRELATION STRUCTURE CLIN CON.

$\bar{x}$ (1 hr.) = 2.60, S^2 (1 hr.) = 0.96, Violation Level* = 3.10														
Uncorrelated data $\phi_1 = 0, \phi_2 = 0$			Low-Medium Correlation $\phi_1 = 0.3, \phi_2 = 0.3$				Medium Correlation $\phi_1 = 0.5, \phi_2 = 0.3$				High Correlation $\phi_1 = 0.7, \phi_2 = 0.2$			
N	Yr. with N Violation	(N x M)	N	Yr. with N Violation	(N x M)	N	Yr. with N Violation	(N x M)	N	Yr. with N Violation	(N x M)	N	Yr. with N Violation	(N x M)
0	13	0	23	1	23	49	1	49	64	1	64	64	1	64
1	24	24	25	1	25	52	1	52	68	2	136	68	2	136
2	26	52	26	1	26	53	3	159	69	3	207	69	1	69
3	19	57	27	1	27	54	3	162	76	2	152	76	2	152
4	10	40	28	2	56	57	1	57	78	1	78	78	1	78
5	5	25	29	1	29	58	3	174	79	3	237	79	3	237
6	1	6	30	2	60	59	3	177	80	3	240	80	3	240
7	2	14	31	2	62	60	3	180	81	1	81	81	1	81
TOTAL	100	218	32	4	64	61	1	61	82	3	246	82	3	246
Average no. of violation/yr. = 2.18			33	6	132	62	2	124	83	4	332	83	4	332
			34	6	204	63	3	189	84	3	252	84	3	252
			35	5	175	64	6	384	85	5	425	85	5	425
			36	2	72	65	1	65	86	5	430	86	5	430
			37	11	407	66	9	594	87	11	957	87	11	957
			38	8	304	67	5	335	88	2	176	88	2	176
			39	4	156	68	5	340	89	4	356	89	4	356
			40	8	320	69	4	276	90	4	360	90	4	360
			41	8	328	70	6	420	91	6	546	91	6	546
			42	5	210	71	6	426	93	3	273	93	3	273
			43	2	86	72	2	144	94	2	188	94	2	188
			44	5	220	73	3	219	95	3	282	95	3	282
			45	2	90	74	4	296	96	3	288	96	3	288
			46	5	230	75	3	225	97	10	970	97	10	970
			47	2	94	76	3	228	98	2	196	98	2	196
			48	2	96	77	4	308	99	4	396	99	4	396
			49	2	98	79	2	158	100	4	400	100	4	400
			50	1	50	80	2	160	101	3	303	101	3	303
			52	1	52	81	3	243	102	1	102	102	1	102
			54	2	108	82	2	164	103	1	103	103	1	103
			55	1	55	85	1	85	104	1	104	104	1	104
			57	1	57	86	2	172	112	1	112	112	1	112
			TOTAL	100	3,916	88	1	88	120	1	120	120	1	120
Average no. of violation/yr. = 39.16			TOTAL				TOTAL				TOTAL		TOTAL	
							100				6,874		100	
													8,994	
													Average no. of violation/yr. = 89.94	

*violation level is taken as the SIP value and is equal to $(\bar{x} + 2.5\sqrt{S^2/24})$

The simulation can be carried out by the subroutine FTGEN in IMSL. The histograms are given in Figures 9-4 and 9-5 for ROM coal and clean coal respectively. Note that the histograms are basically symmetrical about the mean, a result attributed to the large number of data points (36,500 discrete data points); the histograms based on time series generation are broader and less peaked than the corresponding Gaussian curve whose variance has been estimated from half-hour data; the tails of time series-generated histograms drop off more slowly than the corresponding Gaussian curve; and the difference between the histogram and the corresponding Gaussian curve is more marked for clean coal.

The correct cut-off emission limit determined by time series analysis can be estimated roughly from the histograms, and more precisely from the computer output. A comparison of the cut-off emission and the Gaussian emission limit (i.e., the emission rate exceeded only twice per year assuming independent data) is given below:

lb SO ₂ /10 ⁶ Btu	ROM COAL	CLEAN COAL
Mean, $\bar{x}$ (1/2 hr)	5.74	4.39
Variance, S^2 (1/2 hr)	0.8087	0.1957
Gaussian Emission Limit	6.065	4.55
Cut-off Emission Limit	6.175	4.755

The table above illustrates the large difference between the emission limit that is based on the assumption of independent data and the cut-off emission that is based on the correlated structure of the coal. The spread between the cut-off emission and Gaussian emission limit is more pronounced for clean coal. Because clean coal exhibits the stronger correlation structure, one may surmise that broad histograms and heavy tails are produced by correlated data (see Figure 9-5). Under such circumstances, the area under the histogram to the right of the cut-off emission occupies a

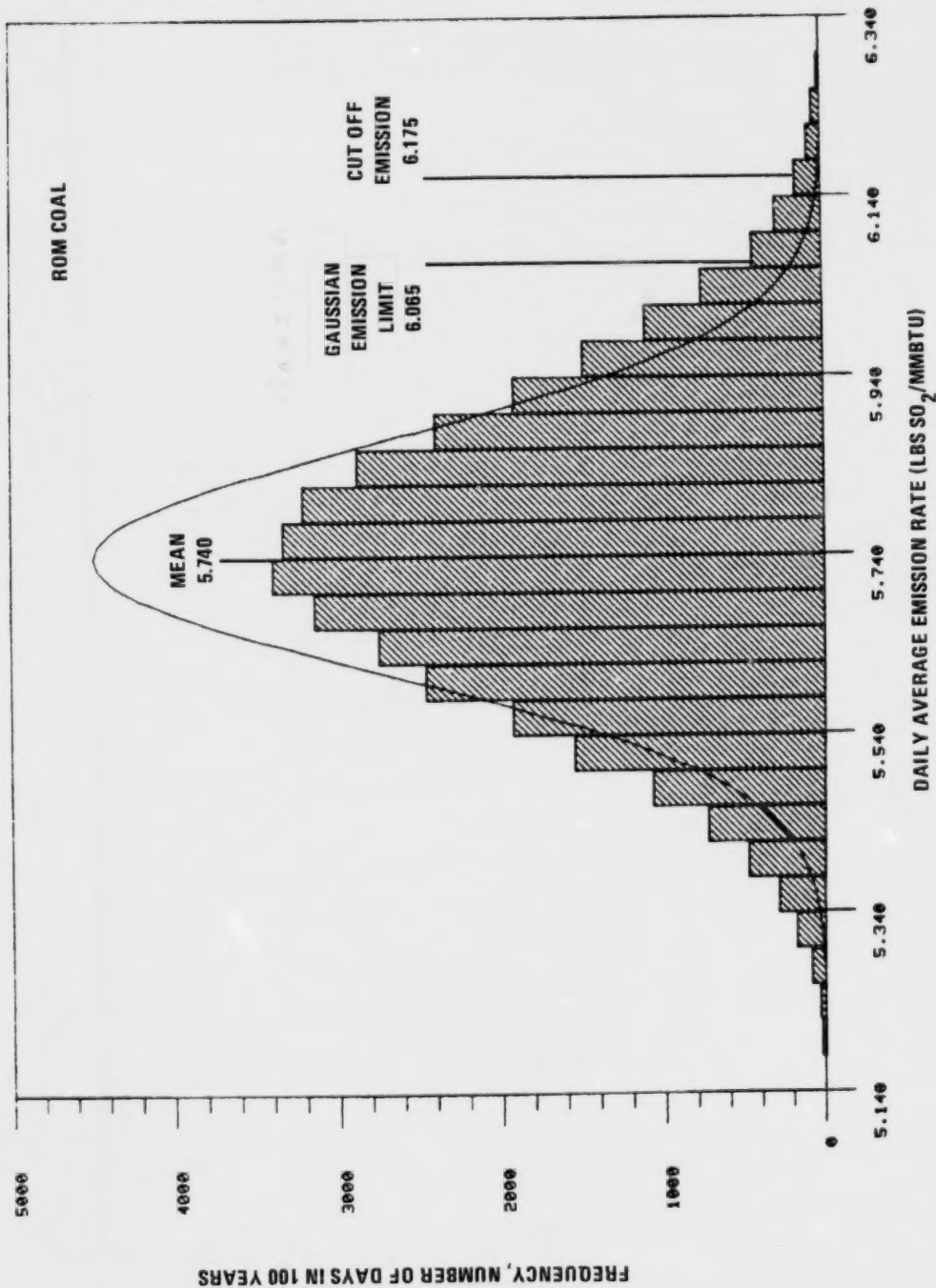


FIGURE 9-4. R & F COAL COMPANY - HISTOGRAM OF DAILY AVERAGE EMISSION RATE BASED ON 100 YEAR TIME SERIES GENERATION AT 30 MINUTE INCREMENTS, ROM COAL

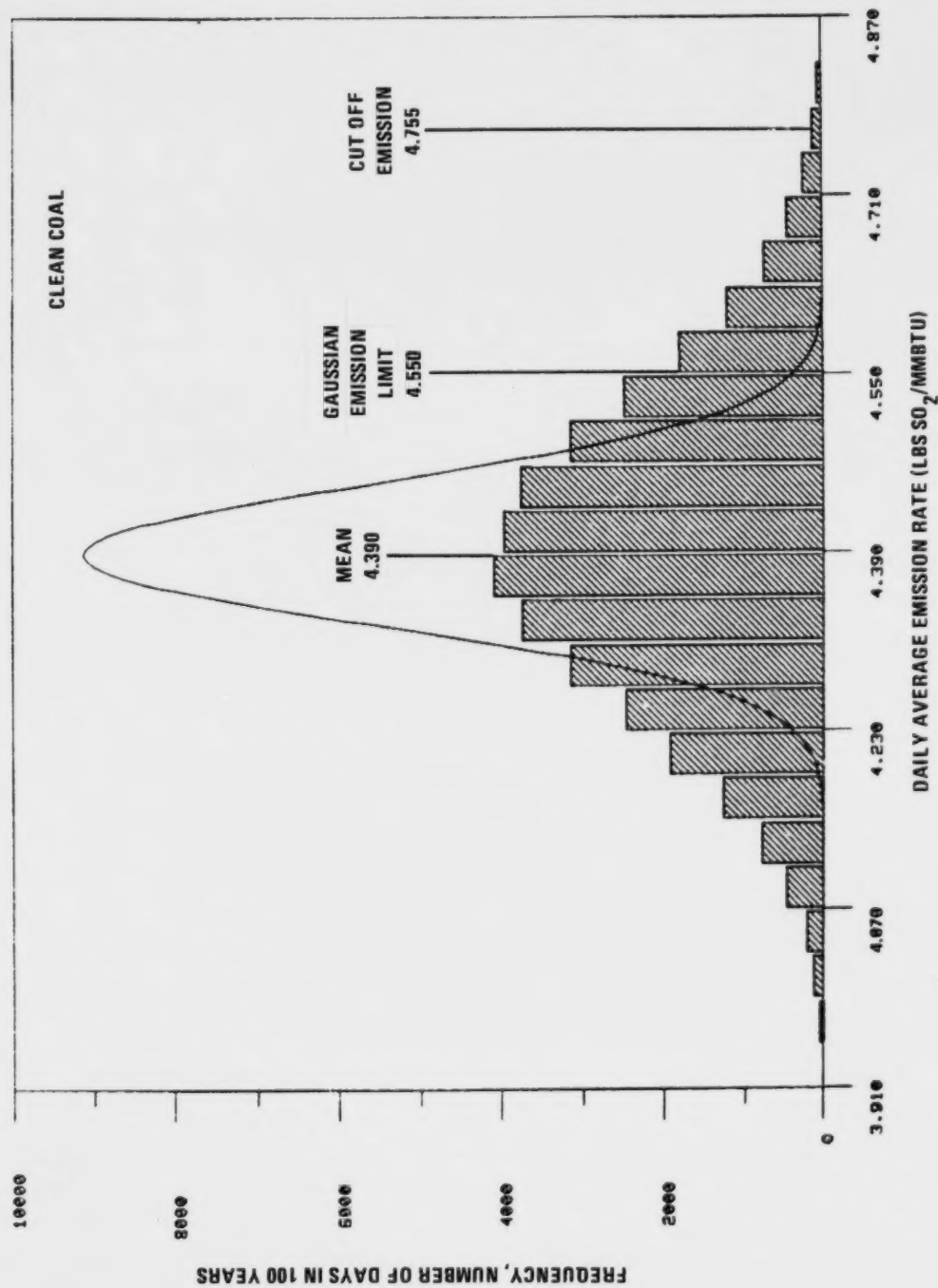


FIGURE 9-5. R & F COAL COMPANY - HISTOGRAM OF DAILY AVERAGE EMISSION RATE BASED ON 100 YEAR TIME SERIES GENERATION AT 30 MINUTE INCREMENTS, CLEAN COAL

larger proportion of the total area than in a Gaussian curve whose variance has been estimated from half-hour data, resulting in a greater number and magnitude of high emission values.

Relationship of Averaging Time to Variance

In order to investigate the effect of averaging time on the sample mean variance of the generated data, these data were plotted as in Figures 9-6 to 9-8. These figures illustrate the computer-generated time series for ROM coal and clean coal, respectively, at half-hour intervals for 100 data points. The top curves represent uncorrelated data and the bottom curves represent correlated data with the same mean and variance. These figures show that the peaks and valleys in the time series for uncorrelated data are randomly distributed, while the peaks and valleys in time series for the correlated data are grouped together. This leads to the expectation that if one mathematically composites these half-hour data into non-overlapping 24-hour intervals, the 24-hour sample mean variance is larger for correlated data than for uncorrelated data.

The corresponding time series of ROM coal data were composited at 24-hour intervals for 365 days as shown in Figure 9-9. The top curve was developed from the uncorrelated data and the bottom curve represents the correlated data. Figure 9-10 is a similar graph for clean coal, and Figure 9-11 is a comparison of correlated data for ROM versus clean coal. Visual inspection of these graphs reveals that (1) the sample mean variance is larger for the correlated data than for the uncorrelated data, and (2) for correlated data, the ROM coal has a larger sample mean variance than the clean coal.

A known relationship between sample mean variance and number of data points was used to check the validity of the time series results for uncorrelated data. This was done by first mathematically compositing the half-hour time series into 1-hour, 2-hour, 3-hour, 12-hour, and 24-hour intervals and calculating their variances about the sample mean. The results were plotted as the averaging time or number of samples, N , versus the mean sample variance for correlated and uncorrelated data.

ROM COAL

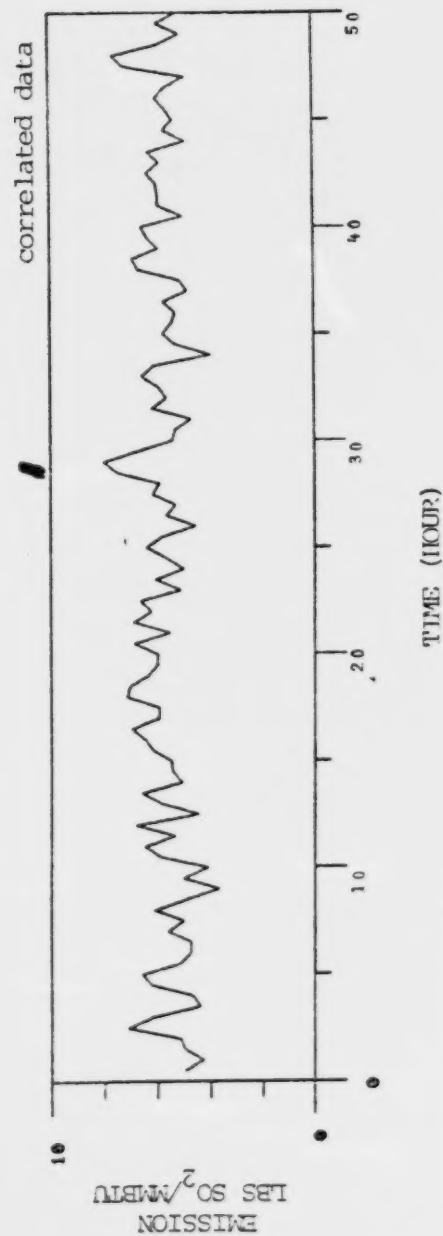
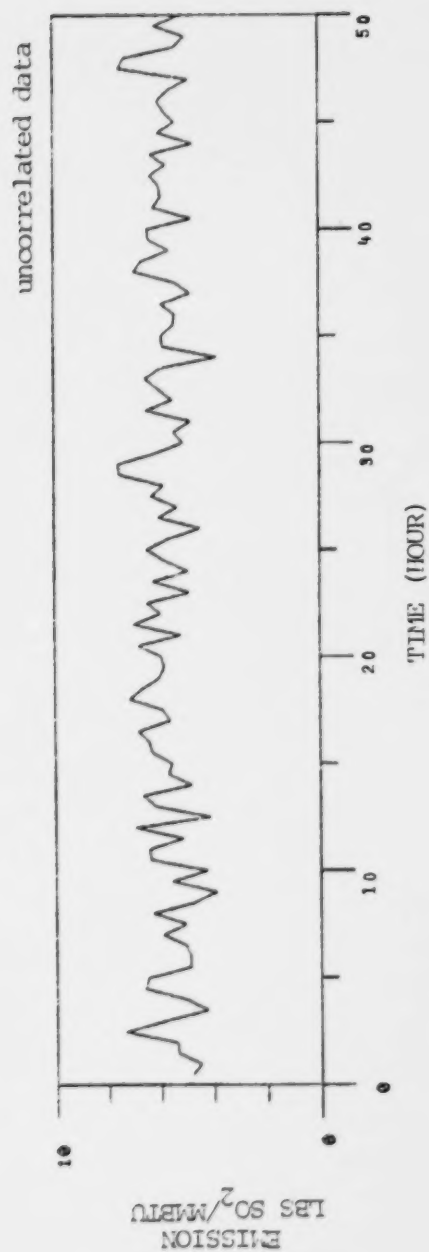


Figure 9-6. R&F Coal Company - ROM coal emission rate from 50-hour time series generation at 30-minute increment, uncorrelated vs. correlated data.

CLEAN COAL

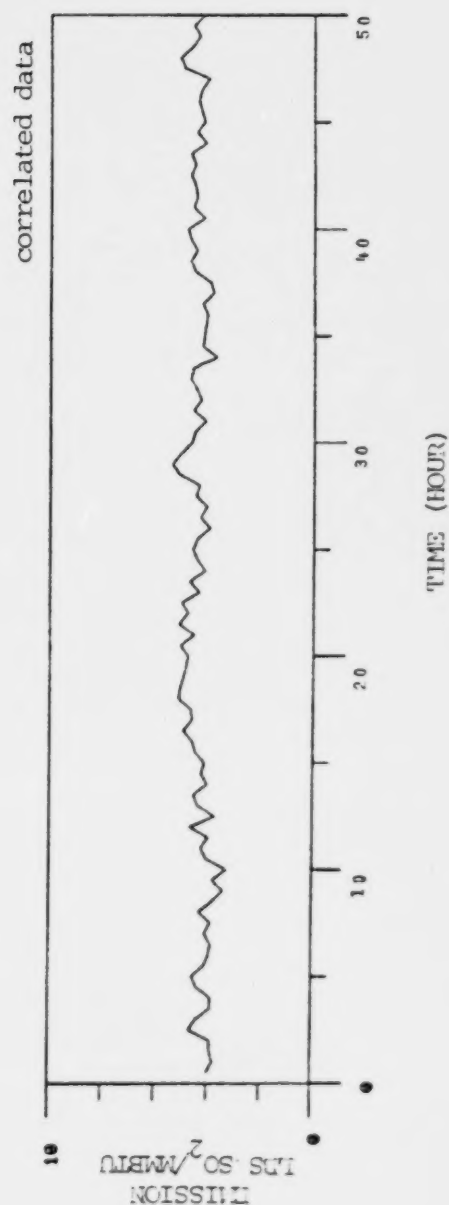
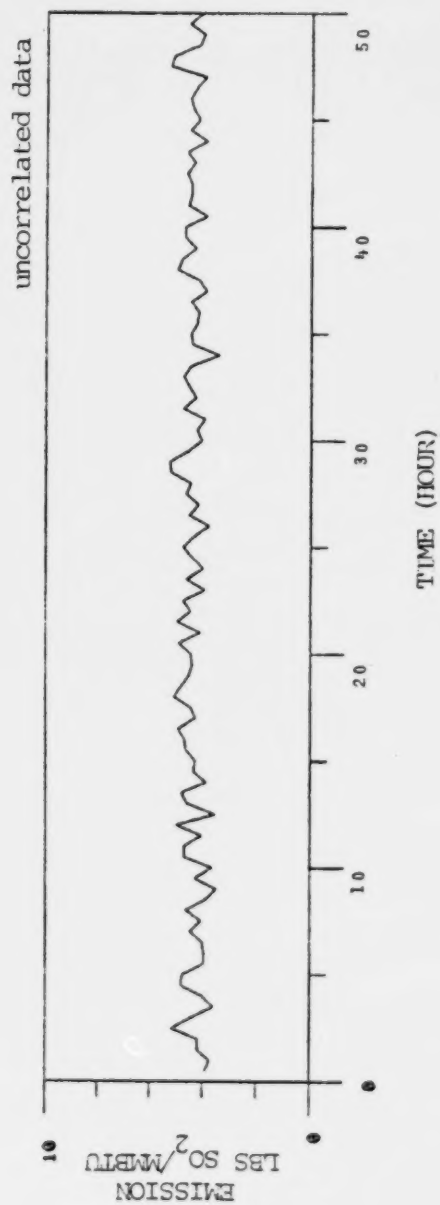


Figure 9-7. R&F Coal Company - clean coal emission rate from 50-hour time series generation at 30-minute increment, uncorrelated vs. correlated data.

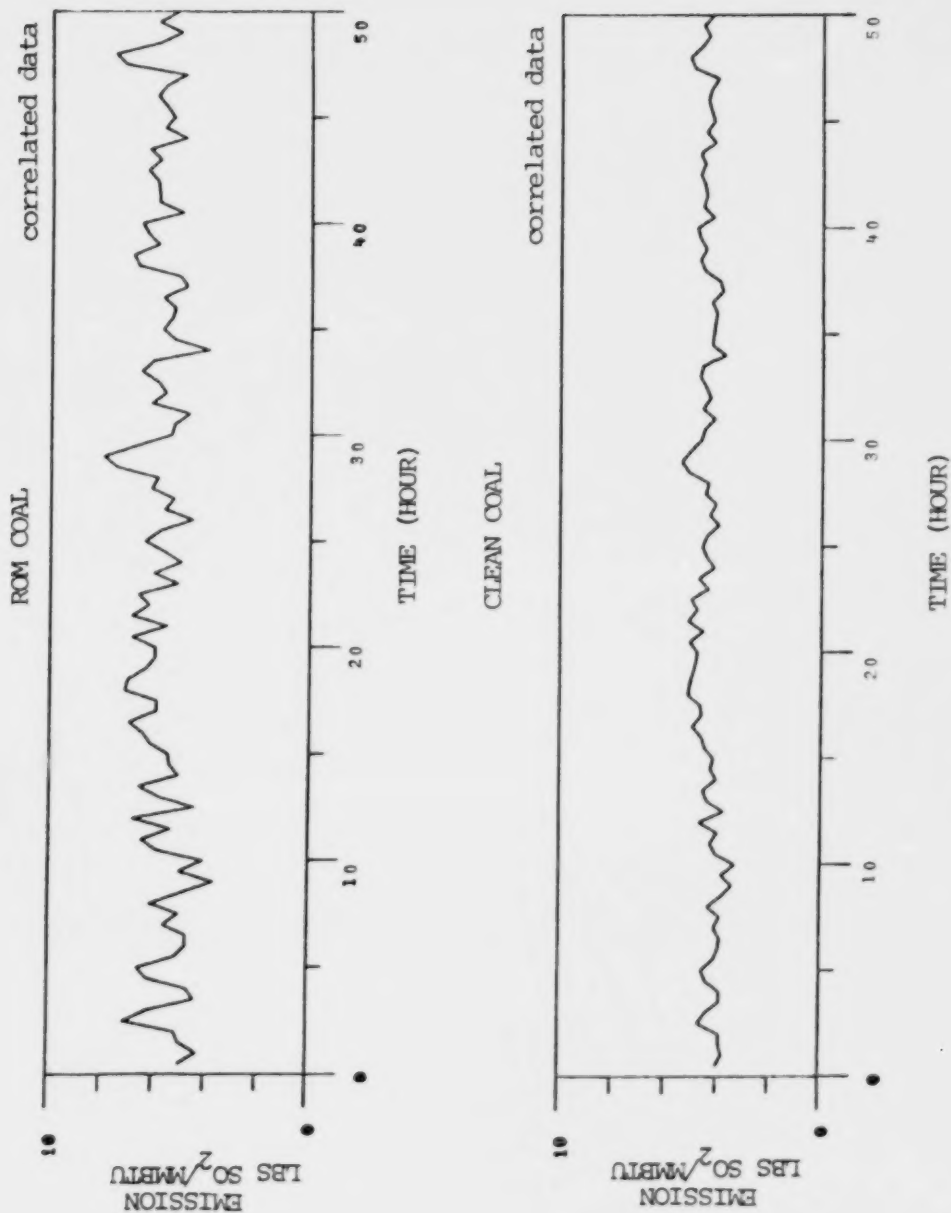


Figure 9-8. R&F Coal Company - emission rate from 50-hour time series generation at 30-minute increment, ROM coal vs. clean coal.

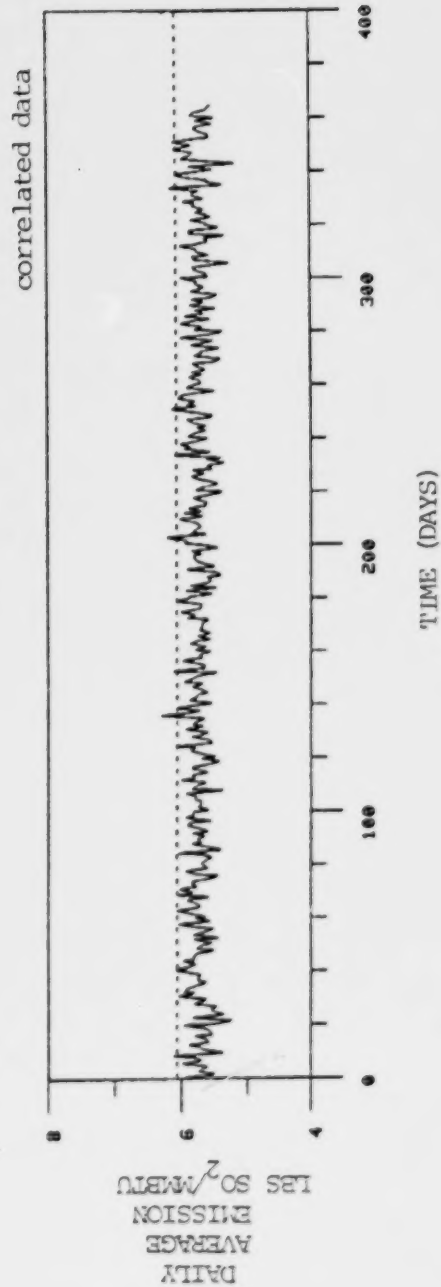
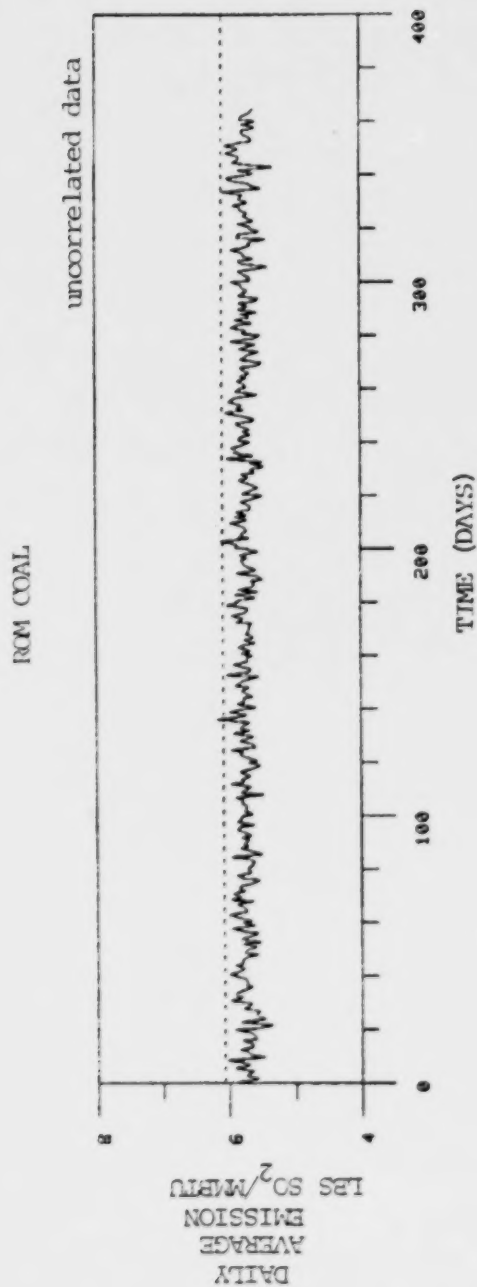


Figure 9-9. R&F Coal Company - ROM coal emission rate from 24-hour composite of time series generation at 30-minute increment, uncorrelated vs. correlated data.

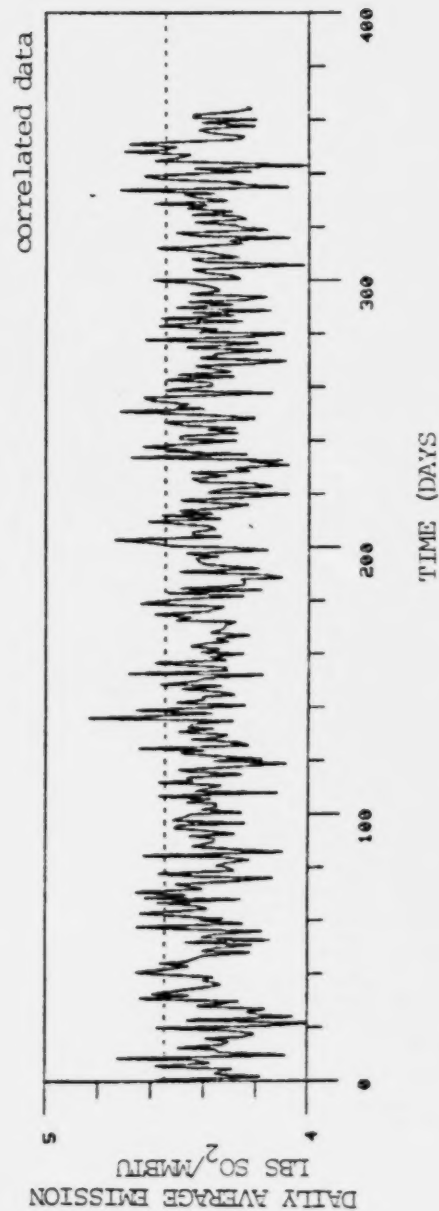
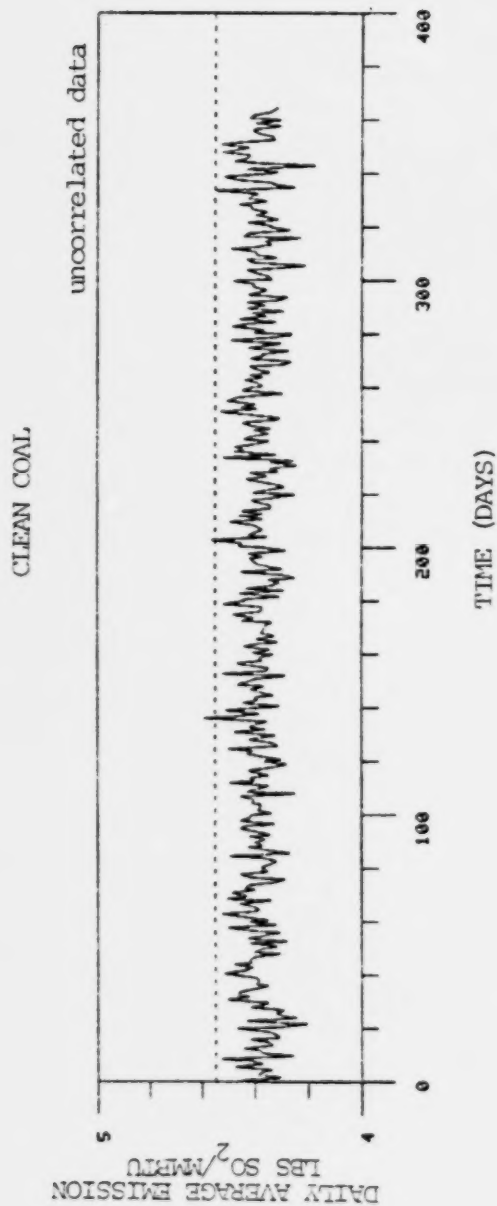


Figure 9-10. REF Coal Company - clean coal emission rate from 24-hour composite of time series generation at 30-minute increment, uncorrelated vs. correlated data.

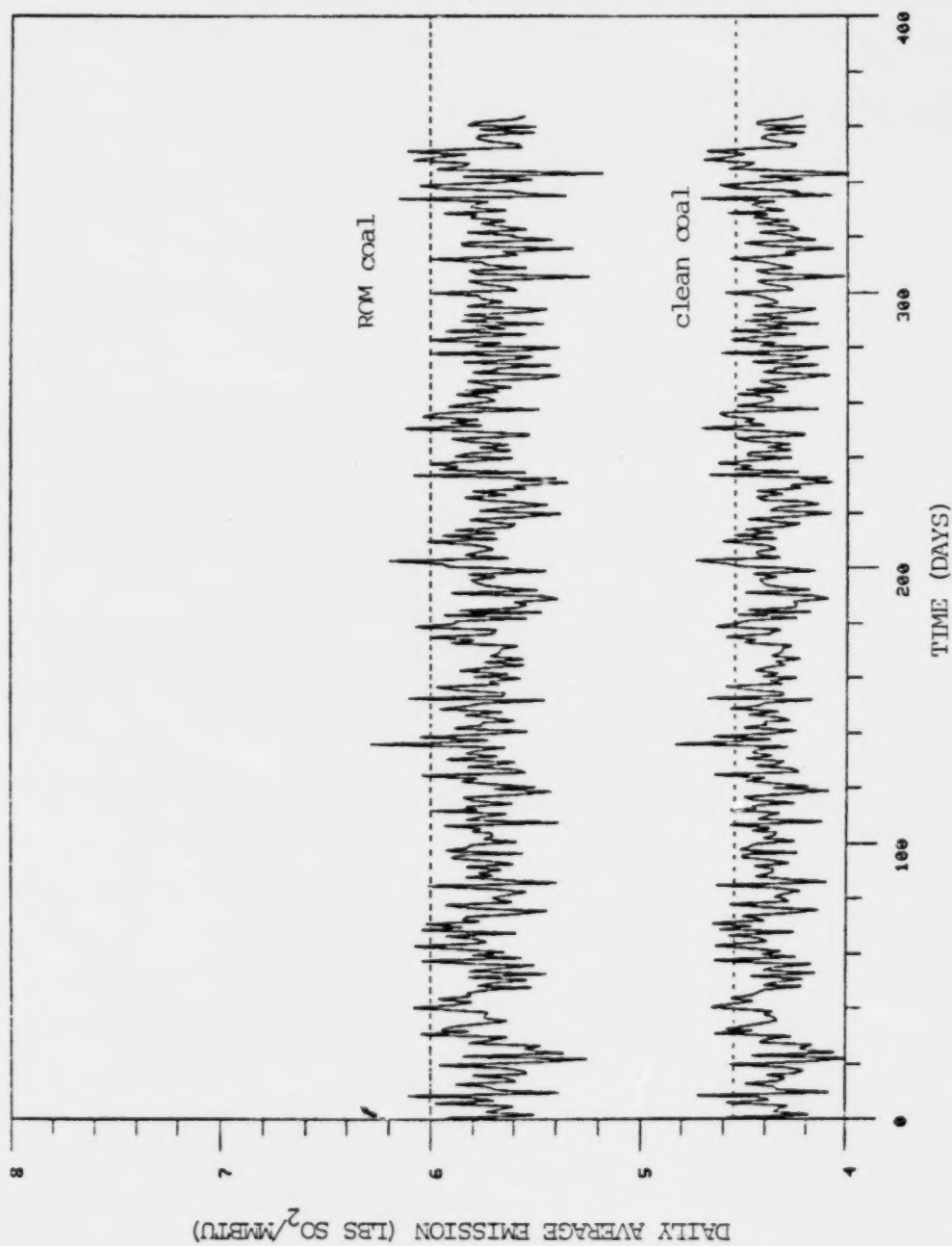


Figure 9-11. R&F Coal Company - emission rate from 24-hour composite of time series generation at 30-minute increment, ROM coal vs. clean coal.

According to the Central Limit Theorem of Gaussian statistics, for independent data possessing a Gaussian distribution, the variance of the sample means change inversely as the number of data points (reference lots). This may be expressed as

$$S_N^2 = S^2/N$$

where: S_N^2 = the variance of the composite of N reference lots (sample size N);
 S^2 = the variance of the individual points; and
 N = the number of reference lots in each composite.

A curve of this equation incorporating the variance of the original data sets was superimposed on the plotted points from the uncorrelated sets of data (see Figure 9-12 and 9-13). The theoretical curve is shown to fit the calculated points for the uncorrelated data very well. This corroborates the validity of the time series analysis as applied to uncorrelated data, and implies its validity for the correlated data as well.

There are fundamental reasons why the sample mean variance exhibits an inverse relationship with sample size, (i.e., averaging time, or lot size). It is well established in mining engineering that the dispersion of sample values within a fixed domain (in this case, one year) decreases, as the support size (in this case, averaging time) increases. The reason is simple. Small lot sizes tend to be individually more uniform in sample value, with high values in some units and low values in others. As a result, one observes larger deviations from the overall mean and thus a larger sample mean variance. Conversely, larger lot sizes contain a mixture of high and low values, and the high and low values balance out in calculating the sample mean. Thus, the sample mean of larger lot sizes is closer to the overall mean (i.e., the sample mean variance is smaller for larger lot sizes).

This type of heuristic argument is applicable to both the uncorrelated data and correlated data. However, Figures 9-12 and 9-13 show unambiguously that the curves predicted by uncorrelated data lie consistently below that predicted by correlated data. These results indicate that statistics that assume independent, uncorrelated data tend to underestimate the

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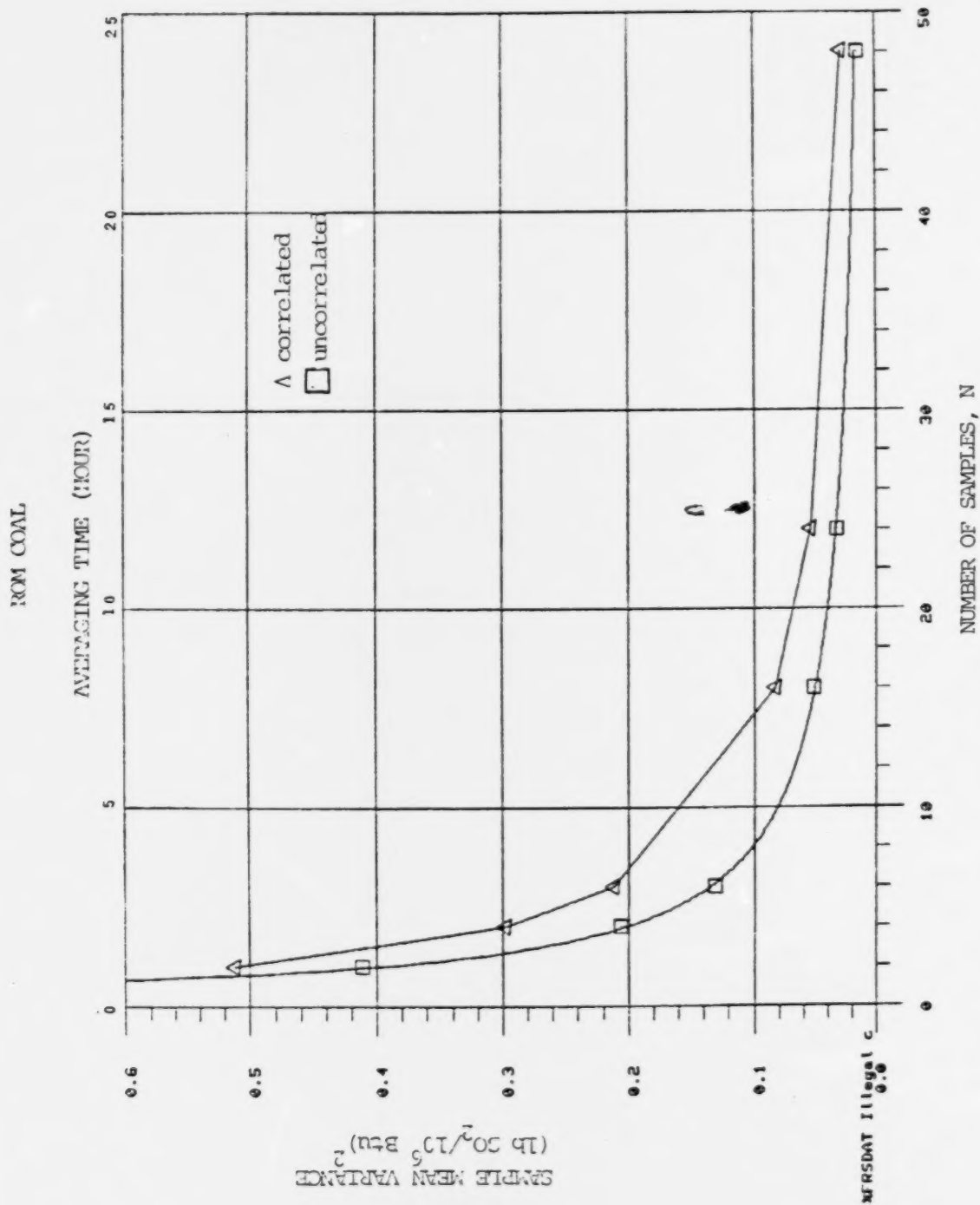


Figure 9-12. ROM Coal Company - sample mean variance of ROM coal as a function of averaging time, uncorrelated vs. correlated data.

CLEAN COAL

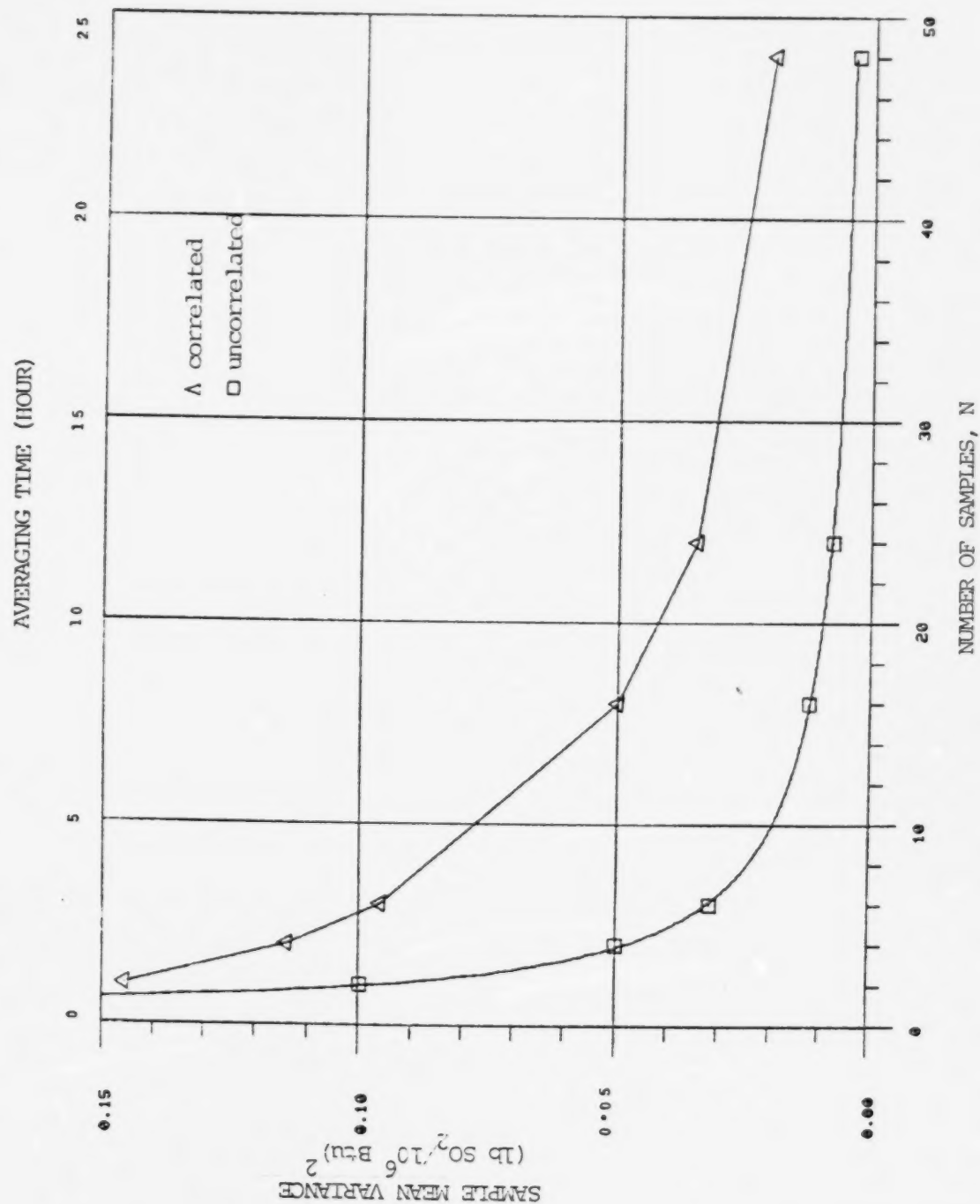


Figure 9-13. R&F Coal Company - sample mean variance of clean coal as a function of averaging time, uncorrelated vs. correlated data.

population variance of correlated data. Figure 9-14 compares the correlated data for ROM and clean coal, and shows the reduction in sample mean variance effected by coal cleaning.

SUMMARY OF TIME SERIES ANALYSIS

The technique of time series analysis has been used to quantify the correlated and random components of the variability in coal data. These values can be directly compared to the values generated by the geostatistical analysis. Although differences exist, the magnitudes and relative order among the data sets are comparable for both types of analysis.

Time-series models can be used to extrapolate predicted values of data sets much longer than the empirical (measured) data set. From a large number of time series based upon the model for the R&F-B/C coal data set, the average number of emission violations by a power plant burning this coal (either raw or cleaned) was determined.

For an emission limit 2.5 standard deviations greater than the mean, and for a 24-hour averaging time, 12 violations per year were predicted for raw coal and 49 for clean coal. In contrast, only two violations per year were predicted from the (erroneous) assumption of serially-independent coal data. Thus the techniques based on statistical independence of data grossly underestimate the average number of emission violations for actual coal. It is found that the histograms based on time series generation are broader, with heavier tails, than the corresponding Gaussian curve. These major findings illustrate the deficiency of techniques based on statistical independence, which underestimates the sample mean variance for correlated data.

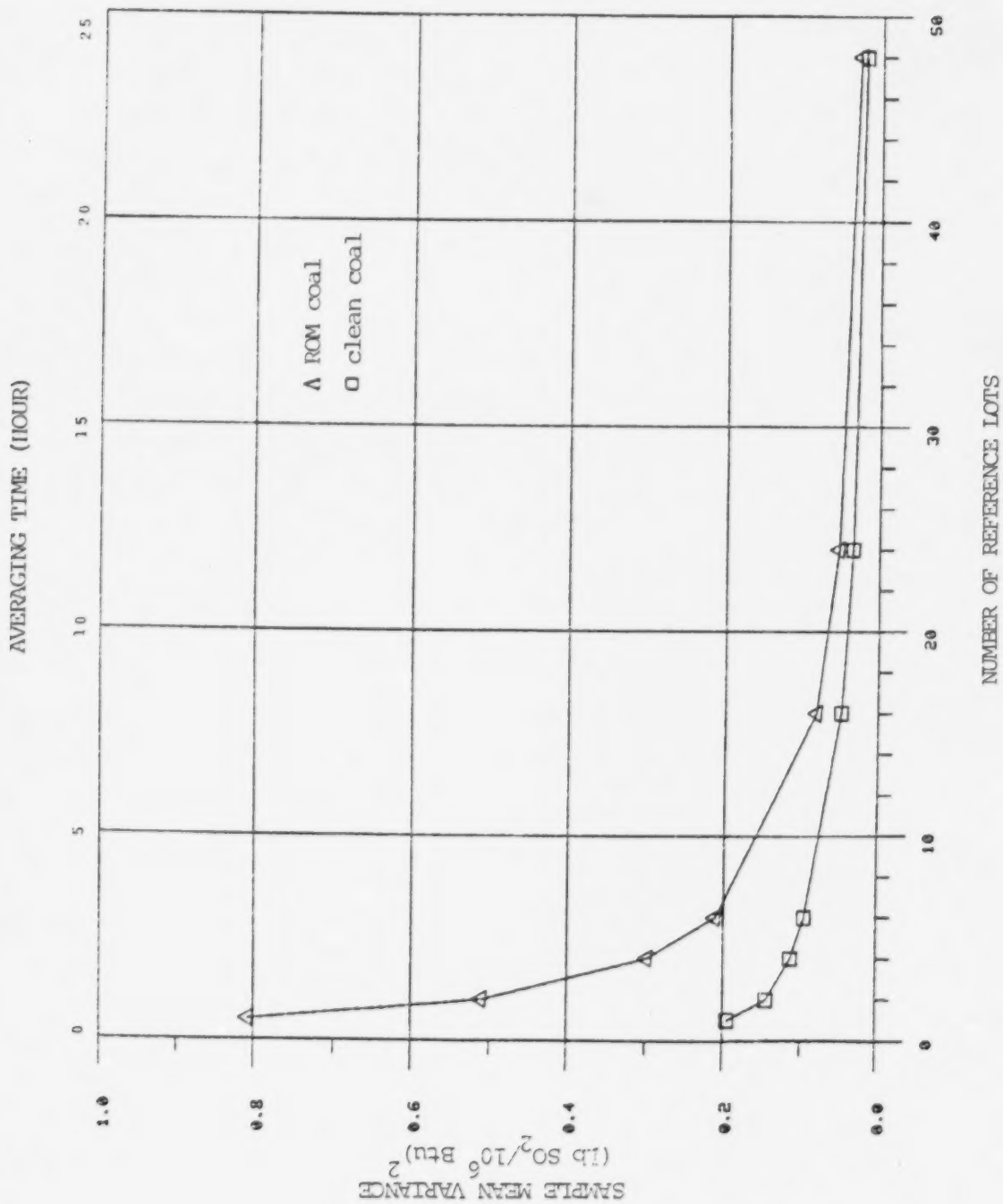


Figure 9-14. R&F Coal Company - sample mean variance as a function of averaging time, ROM coal vs. clean coal.

SECTION 10.0

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APPENDIX A
ANALYTICAL DATA FROM
R&F COAL COMPANY
AND
REPUBLIC STEEL CORPORATION

APPENDIX A

The following tables present all of the data which was generated during the analysis of samples collected at the R&F Coal Company and the Republic Steel Corporation facilities. All tests were performed in duplicate and both analytical values are listed in the data tables as sample code .1 for the first duplicate and sample code .2 for the second. The data is subdivided into the following sections:

- A.1 R&F Coal Company, 30-Minute Increment Data for 22 Hours, ROM and Clean Coal
- A.2 R&F Coal Company, 30-Minute Increment Data for 40 Hours, ROM and Clean Coal
- A.3 R&F Coal Company, 8-Hour Composite Data, ROM and Clean Coal
- A.4 R&F Coal Company, Daily, Weekly and Monthly Composite Data, ROM and Clean Coal
- A.5 R&F Coal Company, In-House Analytical Data, Clean Coal
- A.6 Republic Steel Corporation, Hourly and Half-Hour Incremental Data, ROM and Clean Coal
- A.7 Republic Steel Corporation, Daily, Weekly and Monthly Composite Data, ROM and Clean Coal
- A.8 R&F Coal Company, Data for Raw Coal by Stockpile
- A.9 R&F Coal Company, Data for Clean Coal from Discrete Stockpiles

The following analytical notes and abbreviations apply to the information on the data tables:

- Sample Codes - specific sample descriptions in Section 4 and Appendix C.

- Air Dry Loss (ADL) - weight loss due to evaporation at room temperature, expressed as percent weight loss.
- Residual Moisture (RM) - weight loss due to evaporation at 104°C, expressed as percent weight loss.
- Total Moisture (TM) - $(1 - \frac{ADL}{100}) RM + ADL$.
- Ash Content - residue remaining after heating the sample to 750°C, expressed as weight percent.
- Total Sulfur (TS) - sum of pyritic, organic and sulfate forms of sulfur, expressed as weight percent.
- Pyritic Sulfur (PS) - the form of sulfur associated with iron pyrite (FeS_2), expressed as weight percent.
- Heat Content (Btu/lb) - quantity of heat released by the complete combustion of a known weight of sample.
- "As Determined" Basis - concentration expressed in terms of the moisture present in the analytical sample. The raw data presented in Appendix A is in an "as-determined" basis.
- "Dry" Basis - concentration expressed in terms of zero moisture. Dry weight data is used for all evaluations presented in Sections 5 and 6.
- Zero data (0.00) indicates periods during which samples could not be collected although the preparation plant was operating and processing coal.

A.1 R&F COAL COMPANY - 30-MINUTE INCIDENT DATA FOR 22 HOURS, ROM COAL

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR
A101.1	5.32	1.57	14.41	3.16	11190.	1.55	A130.2	5.77	1.80	22.76	2.58	10684.	1.44
A101.2	5.32	1.57	14.91	3.09	11190.	1.55	A131.1	5.79	1.64	21.94	2.53	10982.	1.32
A102.1	4.04	2.39	15.96	2.81	10993.	1.44	A132.1	5.61	1.72	22.02	2.49	10987.	1.38
A102.2	4.04	2.36	15.83	2.83	10800.	1.44	A132.2	5.61	1.27	21.46	2.51	11138.	1.49
A103.1	5.02	1.61	15.84	2.90	10800.	1.44	A133.1	5.38	1.46	22.48	2.66	10711.	1.55
A103.2	5.02	1.56	15.65	2.85	10960.	1.38	A133.2	5.40	1.22	22.88	2.66	10918.	1.32
A104.1	4.93	1.52	15.48	2.97	11019.	1.61	A134.1	5.40	1.89	23.43	2.89	11121.	1.67
A104.2	4.93	1.59	15.68	2.92	10813.	1.72	A134.2	5.40	1.92	23.24	2.89	11003.	1.67
A105.1	4.69	1.30	16.85	2.97	10966.	2.01	A135.1	5.50	1.94	20.23	3.09	10816.	2.18
A105.2	4.69	1.28	16.82	2.92	11009.	1.84	A135.2	5.50	1.65	20.47	3.20	10938.	2.18
A106.1	4.35	1.07	17.26	3.04	10941.	2.24	A136.1	5.11	1.65	20.32	2.93	10734.	1.55
A106.2	4.35	1.28	17.18	2.90	10864.	2.24	A136.2	5.11	1.70	20.46	3.00	10856.	1.55
A107.1	4.04	1.72	16.55	3.11	10915.	1.95	A137.1	6.20	1.95	20.47	2.97	10878.	1.61
A107.2	4.04	1.48	16.23	3.02	10813.	1.95	A137.2	6.20	1.99	20.53	2.93	10832.	1.67
A108.1	4.53	1.39	17.42	3.18	10846.	1.44	A138.1	5.68	1.64	20.91	2.92	10893.	1.67
A108.2	4.53	1.34	17.64	3.25	10632.	1.44	A138.2	5.68	1.79	20.53	2.99	10895.	1.95
A109.1	5.15	1.65	22.04	2.83	10766.	1.49	A139.1	5.26	2.09	19.18	2.93	10991.	1.67
A109.2	5.15	1.48	21.73	2.74	10928.	1.55	A139.2	5.26	1.73	19.51	2.93	11045.	1.55
A110.1	10.30	1.81	21.69	2.71	10832.	1.55	A140.1	5.46	1.86	21.61	2.95	10792.	2.24
A110.2	10.30	1.53	21.83	2.60	10878.	1.38	A140.2	5.46	1.86	21.47	2.95	10792.	2.24
A111.1	3.80	2.64	21.62	2.67	10797.	1.49	A141.1	5.37	1.58	22.08	2.74	10593.	1.61
A111.2	3.80	2.64	21.29	2.67	10800.	1.38	A141.2	5.37	1.75	22.18	2.80	10656.	1.38
A112.1	4.51	1.50	21.47	2.64	10899.	1.38	A142.1	5.7	2.38	21.55	2.69	10704.	1.44
A112.2	4.51	1.76	20.56	2.76	10892.	1.38	A142.2	5.7	2.38	21.48	2.69	10656.	1.44
A113.1	4.54	1.56	20.68	2.48	10982.	1.38	A143.1	5.54	2.58	20.61	2.62	10569.	1.55
A113.2	4.54	1.63	20.17	2.51	10986.	1.18	A143.2	5.54	2.58	20.61	2.62	10569.	1.55
A114.1	4.88	1.97	20.17	2.51	10984.	1.21	A144.1	5.54	2.68	20.67	2.69	10407.	1.32
A114.2	4.88	1.93	20.31	2.44	11062.	1.03	A144.2	5.58	2.29	21.64	2.83	10730.	1.78
A115.1	5.02	1.70	20.33	2.26	11003.	1.16							
A115.2	5.02	1.65	20.48	2.26	11003.	1.16							
A116.1	4.64	2.01	19.66	2.78	11006.	1.20							
A116.2	4.64	2.05	19.69	2.58	11006.	1.20							
A117.1	4.03	2.50	19.57	2.58	11007.	1.33							
A117.2	4.03	2.47	19.57	2.58	11007.	1.33							
A118.1	5.05	1.59	19.51	2.59	11008.	1.40							
A118.2	5.05	1.60	19.41	2.59	11126.	1.35							
A119.1	5.49	1.47	18.73	2.95	11177.	1.35							
A119.2	5.49	1.68	18.88	2.95	11118.	1.35							
A120.1	5.30	1.78	21.52	2.80	11190.	1.1							
A120.2	5.30	1.82	21.85	2.91	10915.	1.1							
A121.1	5.40	1.90	20.81	2.75	10894.	1.0							
A121.2	5.40	1.64	20.81	2.82	10939.	1.0							
A122.1	5.50	1.66	20.68	2.91	10895.	1.0							
A122.2	5.50	1.66	20.68	2.91	10895.	1.0							
A123.1	4.67	1.81	20.70	2.84	10840.	1.7							
A123.2	4.67	1.81	20.70	2.84	10840.	1.7							
A124.1	4.67	2.04	21.24	2.95	10805.	1.67							
A124.2	4.67	2.04	21.24	2.95	10805.	1.67							
A125.1	4.30	2.65	21.18	2.42	10953.	1.61							
A125.2	4.30	2.65	21.18	2.42	10953.	1.61							
A126.1	4.20	3.00	21.03	2.66	10924.	1.12							
A126.2	4.20	3.00	21.03	2.66	10924.	1.12							
A127.1	4.78	3.45	21.29	2.78	10948.	1.49							
A127.2	4.78	3.45	21.29	2.78	10948.	1.49							
A128.1	5.10	2.46	20.71	2.46	11036.	1.38							
A128.2	5.10	2.46	20.71	2.46	11036.	1.38							
A129.1	5.10	2.67	21.02	2.40	10827.	1.29							
A129.2	5.10	2.67	21.02	2.40	10827.	1.29							
A130.1	5.5	2.26	22.75	2.40	10764.	1.21							
A130.2	5.5	2.26	22.75	2.40	10764.	1.21							
		1.75	22.87	2.46	10905.	1.61							

A.1 R&F COAL COMPANY - 30-MINUTE INCREMENT DATA FOR 22 HOURS, CLEAN COAL.

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR
A201.1	19.29	2.10	14.18	2.25	11852.	1.15	A230.2	4.58	1.16	13.93	2.44	12200.	1.21
A201.2	18.29	2.14	14.13	2.41	11949.	0.98	A231.1	0.00	0.00	0.00	0.00	0.	0.00
A202.1	9.25	2.09	13.61	2.39	12015.	1.21	A232.1	5.97	1.57	12.69	2.46	12284.	1.21
A202.2	9.25	2.08	13.61	2.48	11950.	1.21	A232.2	5.97	1.60	12.73	2.46	12284.	1.26
A203.1	9.62	2.07	14.34	2.18	11566.	1.26	A233.1	6.21	1.56	12.19	2.35	11573.	1.26
A203.2	9.62	2.04	14.34	2.25	11566.	1.21	A233.2	6.21	1.57	12.45	2.34	11520.	1.32
A204.1	9.58	1.17	14.89	2.50	11618.	1.21	A234.1	8.21	1.49	12.71	2.62	11573.	1.49
A204.2	9.58	1.22	14.79	2.85	11725.	1.21	A234.2	8.21	1.38	12.95	2.58	11499.	1.32
A205.1	10.30	1.26	13.83	2.32	12040.	1.21	A235.1	5.13	1.68	12.46	2.39	11752.	1.15
A205.2	10.30	1.28	14.00	2.46	12045.	1.21	A235.2	5.13	1.85	12.30	2.35	11625.	1.15
A206.1	9.20	1.12	15.16	2.16	11984.	1.21	A236.1	5.25	2.06	13.08	2.42	12149.	1.44
A206.2	9.20	0.82	15.02	2.32	11984.	1.21	A236.2	5.25	2.06	13.07	2.44	12042.	1.44
A207.1	0.00	0.00	0.00	0.00	0.	0.00	A237.1	5.25	1.86	13.11	2.46	12324.	1.44
A207.2	0.00	0.00	0.00	0.00	0.	0.00	A237.2	5.25	1.89	13.21	2.53	12324.	1.32
A208.1	7.81	1.06	14.83	2.32	12025.	1.26	A238.1	5.88	1.38	13.82	2.37	12060.	1.44
A208.2	7.81	0.96	14.87	2.27	11942.	1.26	A238.2	5.88	1.16	13.68	2.42	12137.	1.32
A209.1	8.47	1.09	14.95	2.13	11992.	1.26	A239.1	6.68	1.26	14.71	2.39	11767.	1.38
A209.2	8.47	1.22	14.70	2.23	12055.	1.26	A239.2	6.68	1.35	14.59	2.48	12001.	1.38
A210.1	4.97	1.31	15.27	2.25	11877.	1.38	A240.1	5.66	2.29	13.59	2.35	12133.	1.38
A210.2	4.97	1.36	15.21	2.29	11704.	1.38	A240.2	5.66	2.14	13.66	2.35	12058.	1.32
A211.1	8.65	1.04	15.34	2.19	11885.	1.38	A241.1	6.41	1.77	13.59	2.30	11988.	1.26
A211.2	8.65	1.38	15.34	2.28	11773.	1.49	A241.2	6.41	1.68	13.56	2.21	12078.	1.32
A212.1	5.10	1.64	15.33	2.22	11889.	1.26	A242.1	4.73	2.25	13.16	2.42	12034.	1.26
A212.2	5.10	1.57	15.33	2.11	11886.	1.26	A242.2	4.73	2.18	12.96	2.37	11870.	1.44
A213.1	5.46	1.55	15.31	2.29	11919.	1.21	A243.1	8.54	2.37	13.19	2.35	11977.	1.32
A213.2	5.46	1.52	14.80	2.22	11918.	1.09	A243.2	8.54	2.42	13.36	2.32	11976.	1.15
A214.1	5.99	1.36	14.91	2.53	11731.	1.09							
A214.2	5.99	1.43	14.95	2.41	11837.	1.09							
A215.1	5.53	1.43	14.91	2.36	11936.	1.15							
A215.2	5.53	1.32	14.86	2.34	11796.	1.09							
A216.1	4.70	1.65	13.82	2.29	12079.	1.09							
A216.2	4.70	1.52	14.03	2.43	12120.	0.98							
A217.1	4.85	1.55	14.03	2.55	12070.	0.98							
A217.2	4.85	1.53	14.17	2.50	12070.	1.03							
A218.1	4.84	1.53	14.22	2.36	12134.	1.03							
A218.2	4.84	1.33	14.30	2.46	12115.	1.09							
A219.1	4.94	1.46	13.69	2.46	12162.	0.98							
A219.2	4.94	1.51	14.11	2.43	11980.	1.03							
A220.1	5.70	0.79	12.43	2.49	12415.	0.92							
A220.2	5.70	0.75	11.96	2.44	12312.	0.98							
A221.1	5.35	0.52	12.11	2.43	12440.	1.15							
A221.2	5.35	0.67	11.42	2.43	12432.	1.15							
A222.1	5.16	0.96	13.56	2.37	11923.	1.21							
A222.2	5.16	0.94	13.33	2.32	12130.	1.15							
A223.1	5.68	0.88	13.30	2.46	12076.	1.15							
A223.2	5.68	0.90	13.41	2.46	11967.	1.21							
A224.1	5.44	0.84	13.40	2.19	12199.	1.21							
A224.2	5.44	0.84	13.33	2.23	12199.	1.03							
A225.1	4.87	1.56	13.02	2.49	11856.	1.26							
A225.2	4.87	1.23	13.30	2.39	12030.	1.26							
A226.1	4.58	1.32	13.40	2.33	12111.	1.26							
A226.2	4.58	1.01	14.02	2.28	11961.	1.21							
A227.1	4.31	2.35	13.91	2.26	12114.	1.32							
A227.2	4.31	2.03	13.66	2.26	11934.	1.21							
A228.1	5.06	2.14	13.66	2.23	11934.	1.32							
A228.2	5.06	1.93	13.66	2.33	11944.	1.15							
A229.1	4.72	1.93	14.06	2.33	11944.	1.32							
A229.2	4.72	1.53	14.04	2.51	11941.	1.32							
A230.1	4.58	1.48	13.99	2.28	12109.	1.03							

A.2 R&F COAL COMPANY - 30-MINUTE INCREMENT DATA FOR 40 HOURS, RCM COAL.

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR
P101.1	7.75	1.48	21.15	3.82	11779.	1.72	5.18	3.33	17.49	2.96	11639.	1.96
P101.2	7.75	1.59	21.28	2.99	11113.	1.89	4.69	2.80	19.43	3.03	11430.	1.87
P102.1	8.00	1.72	22.39	3.04	10948.	1.89	4.69	1.69	19.17	3.06	11431.	1.96
P102.2	8.00	1.69	22.96	3.13	10955.	1.95	5.67	0.90	19.28	3.19	11372.	2.49
P103.1	6.88	1.47	22.99	3.43	10908.	2.30	5.67	1.23	19.17	3.44	11378.	2.31
P103.2	6.88	1.35	23.12	3.29	10919.	2.53	5.64	1.87	16.34	3.44	11718.	2.15
P104.1	7.28	1.35	22.80	3.32	10961.	2.24	5.64	1.83	16.79	3.35	11694.	2.09
P104.2	7.28	1.48	22.69	3.44	11016.	2.41	5.31	2.17	18.28	3.55	11468.	1.95
P105.1	7.28	1.18	23.22	3.40	10920.	2.24	5.41	2.46	17.96	3.58	11550.	2.23
P105.2	6.92	1.06	23.22	3.21	10941.	2.41	5.41	2.54	18.07	3.67	11561.	2.29
P106.1	6.92	1.87	23.65	3.21	10889.	2.07	5.67	1.93	16.27	3.72	11561.	2.50
P106.2	6.92	1.87	23.57	3.50	10899.	2.35	5.67	1.93	16.27	3.15	11926.	1.69
P107.1	7.14	2.06	22.66	3.00	11249.	1.67	5.10	1.86	17.84	3.09	11926.	1.53
P108.1	6.88	2.08	25.62	2.94	11016.	1.44	5.10	1.80	17.60	3.47	11594.	2.26
P108.2	6.88	2.13	24.24	3.18	10901.	1.84	5.42	0.79	18.01	3.47	11548.	2.24
P109.1	7.26	2.14	21.73	3.46	11036.	2.06	5.42	0.79	17.88	3.65	11549.	2.17
P109.2	7.26	2.20	21.93	3.51	11014.	2.41	5.60	1.27	17.97	3.72	11635.	2.30
P110.1	6.98	0.93	18.88	2.72	11141.	2.12	5.85	1.38	17.88	3.44	11632.	2.48
P110.2	6.98	0.93	18.88	2.69	11192.	2.18	5.85	1.51	19.34	3.78	11664.	2.48
P111.1	7.26	1.17	21.32	3.14	11005.	2.24	5.85	1.51	19.60	3.83	11290.	2.62
P111.2	7.26	1.10	21.32	3.16	11005.	2.24	6.15	1.59	18.31	3.83	11322.	2.25
P112.1	0.00	0.00	0.00	0.00	0.00	0.00	5.60	1.26	18.80	3.76	11450.	2.31
P112.2	0.00	0.00	0.00	0.00	0.00	0.00	5.60	1.49	18.38	3.35	11482.	2.03
P113.1	0.00	0.00	0.00	0.00	0.00	0.00	5.60	1.30	18.65	3.31	11405.	1.95
P113.2	0.00	0.00	0.00	0.00	0.00	0.00	5.68	1.32	19.24	3.33	11067.	1.98
P114.1	0.00	0.00	0.00	0.00	0.00	0.00	5.68	1.74	19.32	3.35	10793.	1.97
P114.2	0.00	0.00	0.00	0.00	0.00	0.00	4.96	1.59	17.58	3.35	11712.	2.10
P115.1	0.00	0.00	0.00	0.00	0.00	0.00	5.66	2.05	17.81	3.28	11460.	1.99
P115.2	0.00	0.00	0.00	0.00	0.00	0.00	5.66	2.05	20.34	3.21	10918.	2.12
P116.1	0.00	0.00	0.00	0.00	0.00	0.00	5.66	1.99	20.87	3.28	11108.	1.95
P116.2	0.00	0.00	0.00	0.00	0.00	0.00	5.73	1.99	22.00	2.96	10780.	2.01
P117.1	0.00	0.00	0.00	0.00	0.00	0.00	5.73	1.85	22.00	2.99	10780.	2.12
P117.2	0.00	0.00	0.00	0.00	0.00	0.00	5.42	1.72	19.66	3.47	11282.	2.41
P118.1	7.46	2.27	20.62	3.25	10914.	1.99	5.87	1.72	20.98	3.56	11373.	2.30
P118.2	6.27	1.93	19.95	3.33	10995.	2.27	5.87	2.06	21.26	2.94	10706.	1.84
P119.1	6.27	1.58	19.77	3.30	11041.	2.41	5.14	1.94	17.51	3.03	10951.	1.84
P119.2	6.33	1.80	20.64	3.21	10907.	2.38	5.14	1.83	17.03	3.10	12133.	1.82
P120.1	6.33	1.80	20.64	3.26	10904.	2.30	5.14	1.85	16.60	3.08	11914.	1.77
P120.2	5.54	2.07	20.59	3.22	10904.	2.40	5.32	1.65	16.86	2.98	10973.	1.70
P121.1	5.54	2.07	20.78	3.26	10977.	2.58	5.44	1.74	14.94	2.85	11052.	1.67
P121.2	5.54	2.07	20.78	3.26	10977.	2.58	5.44	1.74	14.94	2.85	11052.	1.67
P122.1	5.99	1.74	17.50	3.52	10815.	2.34	5.44	1.74	14.94	2.85	11273.	1.60
P122.2	5.99	1.74	17.50	3.52	10815.	2.34	5.80	1.71	16.03	2.89	11282.	1.56
P123.1	6.18	1.76	19.50	3.44	10880.	2.45	5.80	1.71	16.03	3.20	11181.	1.63
P123.2	6.18	1.81	19.68	3.13	11224.	2.60	5.80	1.79	16.10	3.27	11141.	1.51
P124.1	6.08	2.63	19.24	3.17	11563.	2.20	5.52	1.77	18.02	3.25	10599.	1.96
P124.2	6.08	2.73	18.84	3.21	11443.	2.14	5.52	1.80	15.79	3.30	10830.	1.93
P125.1	5.57	2.40	19.17	2.94	11318.	2.12	5.25	1.78	15.82	3.43	11130.	1.93
P125.2	5.57	2.40	19.17	2.94	11318.	2.12	5.77	1.56	14.51	3.20	11517.	2.10
P126.1	5.26	1.62	20.44	2.94	11044.	2.45	5.66	1.37	15.28	3.34	11465.	1.92
P126.2	5.26	1.62	20.44	2.94	11044.	2.45	5.66	1.37	15.21	3.49	10985.	1.87
P127.1	5.12	1.62	12.74	2.33	12385.	1.42	5.28	1.36	17.47	3.91	11008.	2.01
P127.2	5.12	1.62	12.74	2.33	12385.	1.42	5.28	1.36	17.47	3.91	11008.	2.01
P128.1	5.27	1.56	18.58	2.35	11100.	1.41	6.00	1.50	17.70	4.06	10901.	2.41
P128.2	5.27	1.56	18.58	2.35	11100.	1.41	6.00	1.50	17.70	4.06	10901.	2.41
P129.1	5.49	1.61	17.92	2.34	11246.	2.18	6.00	1.64	17.83	5.66	10826.	3.60
P129.2	5.49	1.61	17.92	2.34	11246.	2.18	6.24	1.64	17.83	5.66	10826.	3.60
P130.1	5.18	3.51	17.13	2.81	11701.	2.07	6.24	1.91	16.26	3.10	10759.	1.59
P130.2	5.18	3.51	17.13	2.81	11701.	2.07	6.24	1.91	16.26	3.10	10759.	1.59

A.2 R&F COAL COMPANY - 30-MINUTE INCREMENT DATA FOR 40 HOURS, ROM COAL. (Continued)

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR
C112.1	6.15	1.80	19.86	2.67	18557.	1.26
C112.2	6.15	1.88	19.76	2.75	18590.	1.38
C113.1	5.55	1.36	23.17	3.06	18718.	2.14
C113.2	5.55	1.43	23.00	3.12	18763.	1.93
C114.1	6.81	1.15	23.86	2.72	18427.	1.26
C114.2	6.81	1.00	23.95	2.60	18637.	1.26
C115.1	5.88	1.16	22.47	2.88	18830.	1.78
C115.2	5.88	1.19	22.43	2.83	18798.	1.84
C116.1	6.30	1.10	22.49	2.97	18851.	1.83
C116.2	6.30	1.12	22.49	3.00	18851.	1.84
C117.1	4.59	1.09	22.60	2.81	18834.	1.60
C117.2	4.59	1.14	22.12	2.88	18854.	1.77
C118.1	5.50	1.28	23.69	3.29	18586.	2.08
C118.2	5.50	1.27	23.34	3.45	18786.	2.13
C119.1	5.09	1.42	23.35	2.86	18741.	1.72
C119.2	5.09	1.31	23.87	2.97	18717.	1.72
C120.1	5.06	1.20	23.16	2.83	18834.	1.51
C120.2	5.06	1.37	23.27	2.83	18707.	1.49
C121.1	5.79	1.12	22.98	2.62	18851.	1.36
C121.2	5.79	1.11	23.03	2.60	18810.	1.49
C122.1	5.63	0.69	24.25	3.05	18515.	1.61
C122.2	5.63	0.65	23.95	3.08	18732.	1.32
C123.1	4.91	0.70	23.09	2.76	18915.	1.32
C123.2	4.91	0.76	22.45	2.73	18468.	1.32
C124.1	4.46	0.67	23.41	2.94	12215.	1.93
C124.2	4.46	0.56	23.20	2.97	12294.	1.84
C125.1	5.83	0.74	21.64	2.77	18987.	1.84
C125.2	5.83	0.80	21.68	2.71	18987.	1.56
C126.1	5.51	0.83	24.23	3.00	18629.	1.66
C126.2	5.51	0.80	24.20	2.90	18611.	1.66
C127.1	4.67	1.84	14.55	2.43	11243.	1.20
C127.2	4.67	2.03	14.89	2.48	11243.	1.21
C128.1	1.89	0.81	20.50	3.24	18949.	1.56
C128.2	1.89	0.66	20.74	3.26	18854.	1.92
C129.1	5.43	0.53	21.01	2.98	18948.	1.50
C129.2	5.43	0.53	21.47	2.88	18827.	1.28
C130.1	5.46	0.60	22.60	3.12	18591.	1.62
C130.2	5.46	1.19	22.42	3.02	18626.	1.59
C131.1	5.79	0.75	12.74	2.31	18995.	0.80
C131.2	5.79	0.80	12.74	2.36	18995.	1.04
C132.1	5.26	0.82	20.69	3.31	11381.	1.90
C132.2	5.26	0.63	20.00	3.31	11381.	1.81

A.2 R&F COAL COMPANY - 30-MINUTE INCREMENT DATA FOR 40 HOURS, CLEAN COAL

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	TOTAL SULFUR	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR
B201.1	7.16	1.84	15.58	2.53	12076.	1.21	2.53	12.29	2.53	12343.	1.56
B201.2	7.16	1.83	15.59	2.44	12076.	1.21	2.44	13.26	2.51	12186.	1.43
B202.1	7.28	1.68	13.97	2.55	12080.	1.26	2.55	13.33	2.44	12178.	1.36
B202.2	7.28	1.58	14.02	2.67	12216.	1.21	2.67	11.65	2.81	12569.	1.39
B203.1	6.72	1.25	14.86	2.88	11884.	1.55	2.88	11.10	2.71	12545.	1.36
B203.2	6.72	1.15	14.75	2.89	12034.	1.40	2.89	10.02	3.09	12404.	1.55
B204.1	5.06	1.18	12.03	2.55	12384.	1.38	2.55	10.02	3.11	12343.	1.44
B204.2	5.06	1.32	12.03	2.48	12291.	1.35	2.48	9.02	3.77	12831.	1.40
B205.1	5.32	2.04	12.51	2.59	12186.	1.32	2.59	9.13	3.90	12826.	1.34
B205.2	5.32	2.04	12.63	2.55	12293.	1.55	2.55	9.98	2.98	12675.	1.62
B206.1	4.88	1.71	12.75	2.55	12311.	1.44	2.55	10.47	2.99	12623.	1.60
B206.2	4.88	1.78	12.72	2.39	12381.	1.40	2.39	10.73	2.88	12631.	1.68
B207.1	4.85	1.93	13.38	2.63	12063.	1.55	2.63	0.00	0.00	0.	0.00
B207.2	4.85	1.86	13.39	2.65	12065.	1.40	2.65	0.00	0.00	0.	0.00
B208.1	4.60	2.07	13.11	2.62	12283.	1.44	2.62	10.08	2.89	12689.	1.61
B208.2	4.60	2.22	13.32	2.62	12323.	1.44	2.62	10.08	2.98	12788.	1.66
B209.1	5.00	2.22	11.50	2.36	12340.	1.44	2.36	10.70	3.96	12596.	1.44
B209.2	5.00	2.28	11.55	2.27	12378.	1.40	2.27	10.11	2.83	12572.	1.49
B210.1	4.86	1.41	11.61	2.74	12371.	1.26	2.74	13.18	2.99	12304.	1.34
B211.1	4.86	1.47	11.72	2.87	12371.	1.09	2.87	13.08	2.90	12206.	1.43
B211.2	4.86	2.67	10.27	3.04	12504.	1.38	3.04	10.90	2.87	12549.	1.71
B212.1	5.38	1.31	11.00	3.05	12553.	1.34	3.05	10.82	2.78	12607.	1.62
B212.2	5.38	1.29	11.13	3.05	12481.	1.51	3.05	6.77	2.84	12225.	1.59
B213.1	5.38	0.96	11.07	3.05	12642.	1.46	3.05	7.11	2.92	12396.	1.77
B213.2	5.38	0.96	11.07	3.05	12642.	1.46	3.05	6.90	3.02	12434.	1.60
B214.1	5.38	0.96	11.07	3.05	12642.	1.46	3.05	6.90	3.02	12434.	1.60
B214.2	5.38	0.96	11.07	3.05	12642.	1.46	3.05	6.90	3.02	12434.	1.60
B215.1	5.38	1.81	11.85	2.76	12359.	1.32	2.76	6.90	3.09	12461.	1.78
B215.2	5.38	1.81	11.85	2.76	12359.	1.32	2.76	6.90	3.09	12461.	1.78
B216.1	5.81	3.56	13.01	3.08	12332.	1.37	3.08	6.83	2.86	12437.	1.61
B216.2	5.81	3.56	13.01	3.08	12332.	1.37	3.08	6.83	2.86	12437.	1.61
B217.1	5.42	1.70	13.03	2.58	11907.	1.36	2.58	8.09	2.39	12474.	1.38
B217.2	5.42	1.62	13.03	2.58	12083.	1.34	2.58	8.10	2.32	12479.	1.89
B218.1	5.18	2.33	12.48	2.68	12272.	1.41	2.68	8.34	2.36	12228.	1.44
B218.2	5.18	2.33	12.48	2.68	12272.	1.41	2.68	8.34	2.44	12152.	1.38
B219.1	4.56	0.40	12.19	2.02	12335.	1.46	2.02	8.70	3.02	11985.	1.95
B219.2	4.56	0.40	12.19	2.02	12335.	1.46	2.02	8.70	3.02	11985.	1.95
B220.1	4.56	1.64	11.42	2.37	12078.	1.30	2.37	8.65	2.57	11783.	1.09
B220.2	4.56	1.64	11.42	2.37	12078.	1.30	2.37	8.65	2.57	11783.	1.09
B221.1	4.56	2.02	11.62	2.58	12237.	1.40	2.58	11.27	2.48	11783.	1.15
B221.2	4.56	2.02	11.62	2.58	12237.	1.40	2.58	11.27	2.48	11783.	1.15
B222.1	4.62	1.05	12.43	2.50	12244.	1.52	2.50	10.74	2.59	11859.	1.09
B222.2	4.62	1.05	12.43	2.50	12244.	1.52	2.50	10.74	2.59	11859.	1.09
B223.1	4.53	1.07	12.48	2.56	12237.	1.44	2.56	10.98	2.64	11883.	0.98
B223.2	4.53	1.07	12.48	2.56	12237.	1.44	2.56	10.98	2.64	11883.	0.98
B224.1	4.64	2.37	11.72	2.33	12302.	1.33	2.33	10.63	3.21	12038.	1.32
B224.2	4.64	2.37	11.72	2.33	12302.	1.33	2.33	10.63	3.24	12059.	1.15
B225.1	4.45	2.07	11.74	2.33	12302.	1.30	2.33	10.40	2.64	12254.	1.21
B225.2	4.45	2.07	11.74	2.33	12302.	1.30	2.33	10.40	2.71	12001.	1.26
B226.1	4.28	2.07	12.06	2.51	12313.	1.28	2.51	9.61	3.06	12071.	1.01
B226.2	4.28	2.07	12.06	2.51	12313.	1.28	2.51	9.61	3.06	12071.	1.01
B227.1	4.28	1.25	13.24	2.40	12305.	1.26	2.40	9.60	3.05	11992.	1.21
B227.2	4.28	1.25	13.24	2.40	12305.	1.26	2.40	9.60	3.05	11992.	1.21
B228.1	4.02	1.80	13.05	2.46	12305.	1.37	2.46	9.76	3.02	12057.	1.15
B228.2	4.02	1.80	13.05	2.46	12305.	1.37	2.46	9.76	3.02	12057.	1.15
B229.1	4.70	3.12	10.35	3.69	12233.	1.33	3.69	9.46	3.30	11658.	1.26
B229.2	4.70	3.12	10.35	3.69	12233.	1.33	3.69	9.46	3.30	11658.	1.26
B230.1	4.50	3.43	11.16	2.50	11342.	1.68	2.50	9.67	3.17	11908.	1.50
B230.2	4.50	3.43	11.16	2.50	11342.	1.68	2.50	9.67	3.17	11908.	1.50
B231.1	4.50	3.43	12.21	2.62	12471.	1.42	2.62	8.91	3.56	11922.	1.32
B231.2	4.50	3.43	12.21	2.62	12471.	1.42	2.62	8.91	3.56	11922.	1.32
B232.1	4.50	3.43	12.21	2.62	12471.	1.42	2.62	8.91	2.65	12367.	0.98
B232.2	4.50	3.43	12.21	2.62	12471.	1.42	2.62	8.91	2.65	12367.	0.98
B233.1	4.50	3.43	12.21	2.62	12471.	1.42	2.62	8.91	2.74	12349.	0.92
B233.2	4.50	3.43	12.21	2.62	12471.	1.42	2.62	8.91	2.74	12349.	0.92

A.2 R&F COAL COMPANY - 30-MINUTE INCREMENT DATA FOR 40 HOURS, CLEAN COAL (Continued)

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR
1212-1	0.00	0.00	0.00	0.00	0.	0.00
1212-2	0.00	0.00	0.00	0.00	0.	0.00
1213-1	6.32	1.33	13.08	2.74	11755.	0.80
1213-2	6.32	1.77	13.19	2.60	11614.	0.92
1214-1	6.02	1.26	13.20	2.60	11717.	0.92
1214-2	6.02	1.14	14.03	2.53	11676.	0.92
1215-1	5.45	3.31	13.25	2.49	11567.	0.98
1215-2	5.45	3.22	13.48	2.30	11701.	0.92
1216-1	5.06	3.21	14.78	2.30	11383.	0.80
1216-2	4.97	3.29	14.67	2.42	11579.	0.80
1217-1	4.97	2.39	14.00	2.44	11668.	0.98
1217-2	4.97	2.40	13.85	2.47	11668.	0.80
1218-1	4.97	2.36	13.55	2.53	11794.	1.03
1218-2	4.97	1.81	13.53	2.62	11815.	0.98
1219-1	4.23	1.93	13.14	2.43	11791.	0.86
1219-2	4.23	1.72	13.19	2.41	11817.	0.86
1220-1	2.50	0.95	13.93	2.46	11398.	0.92
1220-2	2.50	0.75	13.55	2.46	11398.	0.92
1221-1	11.07	2.22	15.66	2.44	11899.	0.98
1221-2	11.07	2.26	14.85	2.27	12004.	0.92
1222-1	4.02	2.01	13.82	2.39	12123.	1.18
1222-2	4.02	2.32	14.49	2.55	12123.	1.19
1223-1	4.06	1.95	13.85	2.34	12177.	1.09
1223-2	4.06	1.85	13.53	2.41	12160.	1.11
1224-1	4.44	1.28	15.00	2.30	11973.	1.28
1224-2	4.44	0.95	15.56	2.32	11991.	1.17
1225-1	4.64	1.15	13.74	2.32	12219.	1.07
1225-2	4.64	1.00	13.60	2.13	12174.	1.04
1226-1	3.52	1.10	15.22	2.67	12055.	1.22
1226-2	3.52	1.47	14.93	2.32	12055.	1.13
1227-1	4.67	1.84	14.55	2.43	11243.	1.20
1227-2	4.67	2.03	14.89	2.48	11896.	1.21
1228-1	1.62	1.47	14.17	2.67	11337.	1.42
1228-2	1.62	1.23	14.25	2.62	11337.	1.13
1229-1	4.04	1.80	14.20	2.53	12309.	1.25
1229-2	4.04	1.78	14.20	2.55	12357.	1.02
1230-1	3.81	1.70	14.09	2.46	12118.	1.24
1230-2	3.81	1.06	13.97	2.53	11941.	1.25
1231-1	3.88	1.86	13.04	2.44	12219.	0.98
1231-2	3.88	2.02	13.44	2.60	12225.	1.09
1232-1	4.39	1.98	13.00	2.53	12026.	0.92
1232-2	4.39	2.14	12.92	2.53	12314.	1.21

A.3 R&F COAL COMPANY - 8-HOUR COMPOSITE DATA, RWV CONL.

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR
11-1	4.77	0.86	22.28	2.95	10768.	1.09	0.00	0.00	0.00	0.	0.00
11-2	4.77	0.94	21.94	2.92	10762.	1.21	0.00	0.00	0.00	0.	0.00
12-1	4.22	1.22	22.97	3.32	10919.	1.61	0.00	0.00	0.00	0.	0.00
12-2	4.22	1.15	22.97	3.36	10900.	1.95	0.00	0.00	0.00	0.	0.00
13-1	4.40	0.35	22.81	3.20	10908.	1.49	0.00	0.00	0.00	0.	0.00
13-2	4.40	0.63	23.32	3.20	10947.	1.84	0.00	0.00	0.00	0.	0.00
13-3	4.17	0.55	22.75	3.06	10971.	1.61	0.00	0.00	0.00	0.	0.00
21-1	4.17	0.73	22.12	3.13	10959.	1.72	0.00	0.00	0.00	0.	0.00
22-1	4.16	0.95	22.83	3.20	10887.	1.44	0.00	0.00	0.00	0.	0.00
22-2	4.16	0.95	22.74	3.16	10787.	1.95	0.00	0.00	0.00	0.	0.00
23-1	5.26	0.84	23.89	3.07	10749.	1.55	0.00	0.00	0.00	0.	0.00
23-2	5.26	0.84	23.93	3.27	10755.	1.80	0.00	0.00	0.00	0.	0.00
31-1	3.95	1.72	21.84	3.27	11081.	1.61	0.00	0.00	0.00	0.	0.00
31-2	3.95	1.04	21.69	3.25	11000.	1.44	0.00	0.00	0.00	0.	0.00
32-1	3.95	2.00	22.12	3.46	10900.	1.78	0.00	0.00	0.00	0.	0.00
32-2	3.95	1.92	22.49	3.41	11044.	1.72	0.00	0.00	0.00	0.	0.00
33-1	5.33	1.76	22.48	3.27	10851.	1.78	0.00	0.00	0.00	0.	0.00
33-2	5.33	1.77	22.74	3.29	10838.	1.44	0.00	0.00	0.00	0.	0.00
41-1	2.44	3.57	21.69	3.18	10780.	1.49	0.00	0.00	0.00	0.	0.00
41-2	2.44	3.17	21.46	3.28	10874.	1.61	0.00	0.00	0.00	0.	0.00
42-1	3.18	2.93	22.00	2.93	10737.	1.49	0.00	0.00	0.00	0.	0.00
42-2	3.18	2.93	21.58	2.93	10743.	1.78	0.00	0.00	0.00	0.	0.00
51-1	5.25	1.27	21.08	2.97	11192.	1.72	0.00	0.00	0.00	0.	0.00
51-2	5.25	1.42	20.08	2.85	11217.	1.78	0.00	0.00	0.00	0.	0.00
52-1	5.35	2.27	20.17	2.90	11289.	1.67	0.00	0.00	0.00	0.	0.00
52-2	5.35	2.40	19.80	2.88	11289.	1.61	0.00	0.00	0.00	0.	0.00
53-1	4.78	2.29	20.42	2.71	11163.	1.49	0.00	0.00	0.00	0.	0.00
53-2	4.78	2.52	20.36	2.74	10908.	1.44	0.00	0.00	0.00	0.	0.00
61-1	4.83	2.18	20.54	3.13	11266.	1.44	0.00	0.00	0.00	0.	0.00
61-2	4.83	2.05	20.96	3.13	11135.	1.95	0.00	0.00	0.00	0.	0.00
62-1	5.34	1.90	20.74	3.76	11083.	2.70	0.00	0.00	0.00	0.	0.00
62-2	5.34	2.02	20.62	3.00	11150.	1.95	0.00	0.00	0.00	0.	0.00
71-1	3.61	3.03	21.57	2.67	11570.	1.84	0.00	0.00	0.00	0.	0.00
71-2	3.61	3.07	21.67	2.62	11570.	1.89	0.00	0.00	0.00	0.	0.00
81-1	0.00	0.00	0.00	0.00	0.	0.00	0.00	0.00	0.00	0.	0.00
81-2	0.00	0.00	0.00	0.00	0.	0.00	0.00	0.00	0.00	0.	0.00
91-1	0.00	0.00	0.00	0.00	0.	0.00	0.00	0.00	0.00	0.	0.00
91-2	0.00	0.00	0.00	0.00	0.	0.00	0.00	0.00	0.00	0.	0.00
92-1	0.00	0.00	0.00	0.00	0.	0.00	0.00	0.00	0.00	0.	0.00
92-2	0.00	0.00	0.00	0.00	0.	0.00	0.00	0.00	0.00	0.	0.00
93-1	0.00	0.00	0.00	0.00	0.	0.00	0.00	0.00	0.00	0.	0.00
93-2	0.00	0.00	0.00	0.00	0.	0.00	0.00	0.00	0.00	0.	0.00
94-1	0.00	0.00	0.00	0.00	0.	0.00	0.00	0.00	0.00	0.	0.00
94-2	0.00	0.00	0.00	0.00	0.	0.00	0.00	0.00	0.00	0.	0.00
95-1	0.00	0.00	0.00	0.00	0.	0.00	0.00	0.00	0.00	0.	0.00
95-2	0.00	0.00	0.00	0.00	0.	0.00	0.00	0.00	0.00	0.	0.00
96-1	0.00	0.00	0.00	0.00	0.	0.00	0.00	0.00	0.00	0.	0.00
96-2	0.00	0.00	0.00	0.00	0.	0.00	0.00	0.00	0.00	0.	0.00
97-1	0.00	0.00	0.00	0.00	0.	0.00	0.00	0.00	0.00	0.	0.00
97-2	0.00	0.00	0.00	0.00	0.	0.00	0.00	0.00	0.00	0.	0.00
98-1	0.00	0.00	0.00	0.00	0.	0.00	0.00	0.00	0.00	0.	0.00
98-2	0.00	0.00	0.00	0.00	0.	0.00	0.00	0.00	0.00	0.	0.00
99-1	0.00	0.00	0.00	0.00	0.	0.00	0.00	0.00	0.00	0.	0.00
99-2	0.00	0.00	0.00	0.00	0.	0.00	0.00	0.00	0.00	0.	0.00

A.3 R&F COAL COMPANY - 8-HOUR COMPOSITE DATA, RAW COAL (Continued)

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR
1	0.00	0.00	0.00	0.00	0.	0.00
1	0.00	0.00	0.00	0.00	0.	0.00
1	0.00	0.00	0.00	0.00	0.	0.00
1	0.00	0.00	0.00	0.00	0.	0.00
1	0.00	0.00	0.00	0.00	0.	0.00
1	0.00	0.00	0.00	0.00	0.	0.00
1	0.00	0.00	0.00	0.00	0.	0.00
1	0.00	0.00	0.00	0.00	0.	0.00
1831.1	7.60	1.42	24.78	2.73	18535.	1.74
1831.2	7.60	1.26	24.71	2.71	18603.	1.80
1	0.00	0.00	0.00	0.00	0.	0.00
1	0.00	0.00	0.00	0.00	0.	0.00
1	0.00	0.00	0.00	0.00	0.	0.00
1	0.00	0.00	0.00	0.00	0.	0.00
1731.1	4.90	1.13	24.59	3.03	11062.	2.01
1731.2	4.90	0.83	24.69	3.03	11062.	2.23
1732.1	5.81	2.01	21.99	2.83	11241.	1.20
1732.2	5.81	1.69	21.98	2.88	11241.	1.20
1733.1	5.91	0.97	22.51	3.13	11059.	2.11
1733.2	5.91	0.93	22.36	3.20	11031.	2.17
1831.1	4.75	1.02	23.13	3.78	11178.	2.57
1831.2	4.75	0.57	23.01	3.65	11416.	2.34
1832.1	4.68	0.57	22.08	3.90	11127.	2.38
1832.2	4.68	0.70	22.07	3.82	11127.	2.58
1833.1	5.09	0.41	21.59	2.80	11154.	2.09
1833.2	5.09	0.40	21.72	3.20	11247.	2.22
1931.1	3.68	0.04	24.02	3.07	10869.	2.31
1931.2	3.68	1.02	23.83	3.12	10833.	2.18

A.3 R&F COAL COMPANY - 8-HOUR COMPOSITE DATA, CLEAN COAL

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR
141.1	5.44	0.65	12.59	2.44	12298.	1.32	I	941.1	0.00	0.00	0.00	0.00	0.00
141.2	5.44	0.67	12.78	2.39	12259.	1.15	I	941.2	0.00	0.00	0.00	0.00	0.00
142.1	5.20	0.48	12.69	2.67	12291.	0.93	I	942.1	0.00	0.00	0.00	0.00	0.00
142.2	5.20	0.40	12.94	2.60	12260.	0.92	I	942.2	0.00	0.00	0.00	0.00	0.00
143.1	4.93	0.70	12.20	2.64	12298.	1.21	I	1041.1	0.00	0.00	0.00	0.00	0.00
143.2	4.93	0.58	12.27	2.64	12298.	1.21	I	1041.2	0.00	0.00	0.00	0.00	0.00
241.1	5.04	0.29	13.30	2.41	12419.	1.09	I	1042.1	0.00	0.00	0.00	0.00	0.00
241.2	5.04	0.21	13.46	2.41	12504.	0.90	I	1042.2	0.00	0.00	0.00	0.00	0.00
242.1	5.87	0.36	13.25	2.48	12321.	1.11	I	1043.1	0.00	0.00	0.00	0.00	0.00
242.2	5.87	0.38	13.25	2.44	12325.	1.11	I	1043.2	0.00	0.00	0.00	0.00	0.00
243.1	5.70	0.50	13.78	2.48	12234.	1.09	I	1141.1	0.00	0.00	0.00	0.00	0.00
243.2	5.70	0.40	13.45	2.46	12234.	0.87	I	1141.2	0.00	0.00	0.00	0.00	0.00
341.1	4.54	1.01	12.44	2.78	11459.	1.86	I	1142.1	0.00	0.00	0.00	0.00	0.00
341.2	4.54	0.88	12.41	2.81	11308.	1.21	I	1142.2	0.00	0.00	0.00	0.00	0.00
342.1	4.68	1.57	12.92	2.76	12481.	1.44	I	1143.1	0.00	0.00	0.00	0.00	0.00
342.2	4.68	1.10	12.84	2.78	12371.	1.26	I	1143.2	0.00	0.00	0.00	0.00	0.00
343.1	5.09	1.20	13.24	2.64	12255.	1.26	I	1241.1	0.00	0.00	0.00	0.00	0.00
343.2	5.09	0.95	12.82	2.67	12255.	1.26	I	1241.2	0.00	0.00	0.00	0.00	0.00
441.1	3.60	2.38	13.45	2.74	12279.	1.26	I	1242.1	0.00	0.00	0.00	0.00	0.00
441.2	3.60	2.27	13.37	2.67	12271.	1.44	I	1242.2	0.00	0.00	0.00	0.00	0.00
442.1	3.55	2.35	16.10	2.61	11859.	1.15	I	1341.1	1.89	1.10	12.27	12364.	1.26
442.2	3.55	2.39	16.10	2.64	11859.	1.15	I	1341.2	1.89	1.10	12.27	12364.	1.26
541.1	7.42	1.54	14.72	1.97	12194.	1.15	I	1342.1	5.10	1.32	12.59	12566.	1.26
541.2	7.42	1.48	14.66	2.11	12140.	1.15	I	1342.2	5.10	1.24	12.20	12555.	1.26
1542.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1343.1	4.66	1.12	12.05	12388.	1.27
1542.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1343.2	4.66	0.77	12.27	12388.	1.27
641.1	4.55	1.55	14.00	2.51	12378.	1.40	I	1441.1	4.11	0.55	12.61	12388.	1.20
641.2	4.55	1.56	13.95	2.55	12378.	1.61	I	1441.2	4.11	0.60	12.61	12388.	1.20
642.1	4.82	2.08	11.11	3.13	12678.	1.72	I	1442.1	4.18	0.46	12.11	12631.	1.09
642.2	4.82	1.80	11.14	3.13	12678.	1.72	I	1442.2	4.18	0.58	12.24	12631.	1.09
741.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1443.1	4.24	0.66	13.00	12382.	1.32
741.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1443.2	4.24	0.49	13.31	12470.	1.20
742.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1541.1	6.64	0.78	13.46	12437.	1.08
742.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1541.2	6.64	0.70	13.80	12200.	1.25
841.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1542.1	0.00	0.00	0.00	12132.	0.00
841.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1542.2	0.00	0.00	0.00	0.00	0.00
842.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1543.1	0.00	0.00	0.00	0.00	0.00
842.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1543.2	0.00	0.00	0.00	0.00	0.00
843.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1544.1	0.00	0.00	0.00	0.00	0.00
843.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1544.2	0.00	0.00	0.00	0.00	0.00
844.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1545.1	0.00	0.00	0.00	0.00	0.00
844.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1545.2	0.00	0.00	0.00	0.00	0.00
845.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1546.1	0.00	0.00	0.00	0.00	0.00
845.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1546.2	0.00	0.00	0.00	0.00	0.00
846.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1547.1	0.00	0.00	0.00	0.00	0.00
846.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1547.2	0.00	0.00	0.00	0.00	0.00
847.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1548.1	0.00	0.00	0.00	0.00	0.00
847.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1548.2	0.00	0.00	0.00	0.00	0.00
848.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1549.1	0.00	0.00	0.00	0.00	0.00
848.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1549.2	0.00	0.00	0.00	0.00	0.00
849.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1550.1	0.00	0.00	0.00	0.00	0.00
849.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1550.2	0.00	0.00	0.00	0.00	0.00
850.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1551.1	0.00	0.00	0.00	0.00	0.00
850.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1551.2	0.00	0.00	0.00	0.00	0.00
851.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1552.1	0.00	0.00	0.00	0.00	0.00
851.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1552.2	0.00	0.00	0.00	0.00	0.00
852.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1553.1	0.00	0.00	0.00	0.00	0.00
852.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1553.2	0.00	0.00	0.00	0.00	0.00
853.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1554.1	0.00	0.00	0.00	0.00	0.00
853.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1554.2	0.00	0.00	0.00	0.00	0.00
854.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1555.1	0.00	0.00	0.00	0.00	0.00
854.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1555.2	0.00	0.00	0.00	0.00	0.00
855.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1556.1	0.00	0.00	0.00	0.00	0.00
855.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1556.2	0.00	0.00	0.00	0.00	0.00
856.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1557.1	0.00	0.00	0.00	0.00	0.00
856.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1557.2	0.00	0.00	0.00	0.00	0.00
857.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1558.1	0.00	0.00	0.00	0.00	0.00
857.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1558.2	0.00	0.00	0.00	0.00	0.00
858.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1559.1	0.00	0.00	0.00	0.00	0.00
858.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1559.2	0.00	0.00	0.00	0.00	0.00
859.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1560.1	0.00	0.00	0.00	0.00	0.00
859.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1560.2	0.00	0.00	0.00	0.00	0.00
860.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1561.1	0.00	0.00	0.00	0.00	0.00
860.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1561.2	0.00	0.00	0.00	0.00	0.00
861.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1562.1	0.00	0.00	0.00	0.00	0.00
861.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1562.2	0.00	0.00	0.00	0.00	0.00
862.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1563.1	0.00	0.00	0.00	0.00	0.00
862.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1563.2	0.00	0.00	0.00	0.00	0.00
863.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1564.1	0.00	0.00	0.00	0.00	0.00
863.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1564.2	0.00	0.00	0.00	0.00	0.00
864.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1565.1	0.00	0.00	0.00	0.00	0.00
864.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1565.2	0.00	0.00	0.00	0.00	0.00
865.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1566.1	0.00	0.00	0.00	0.00	0.00
865.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1566.2	0.00	0.00	0.00	0.00	0.00
866.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1567.1	0.00	0.00	0.00	0.00	0.00
866.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1567.2	0.00	0.00	0.00	0.00	0.00
867.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1568.1	0.00	0.00	0.00	0.00	0.00
867.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1568.2	0.00	0.00	0.00	0.00	0.00
868.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1569.1	0.00	0.00	0.00	0.00	0.00
868.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1569.2	0.00	0.00	0.00	0.00	0.00
869.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1570.1	0.00	0.00	0.00	0.00	0.00
869.2	0.00	0.00	0.00	0.00	0.00	0.00	I	1570.2	0.00	0.00	0.00	0.00	0.00
870.1	0.00	0.00	0.00	0.00	0.00	0.00	I	1571.1	0.				

A.3 R&F COAL COMPANY - 8-HOUR COMPOSITE DATA, CLEAN COAL (Continued)

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR
1641.1	0.00	0.00	0.00	0.00	0.	0.00
1641.2	0.00	0.00	0.00	0.00	0.	0.00
1642.1	0.00	0.00	0.00	0.00	0.	0.00
1642.2	0.00	0.00	0.00	0.00	0.	0.00
1643.1	0.00	0.00	0.00	0.00	0.	0.00
1643.2	0.00	0.00	0.00	0.00	0.	0.00
1741.1	0.00	0.00	0.00	0.00	0.	0.00
1741.2	0.00	0.00	0.00	0.00	0.	0.00
1742.1	4.51	1.56	13.04	0.00	12408.	0.
1742.2	4.51	1.58	12.85	2.55	12473.	1.49
1743.1	4.55	0.85	15.46	2.59	12473.	1.44
1743.2	4.55	1.24	15.46	2.63	12488.	1.32
1744.1	4.46	1.04	14.38	2.61	12637.	1.20
1744.2	4.46	0.97	13.86	2.60	12815.	1.43
1745.1	6.92	1.72	14.38	2.62	12755.	1.54
1745.2	6.92	1.66	14.22	2.65	12443.	1.43
1746.1	4.67	1.13	15.07	2.60	12280.	1.49
1746.2	4.67	1.61	14.98	2.46	12460.	1.32
1747.1	4.66	1.36	11.64	2.51	12460.	1.21
1747.2	4.66	1.35	11.75	2.67	12317.	1.49
1841.1	3.24	1.73	12.90	2.62	12317.	1.55
1841.2	3.24	1.73	12.65	2.76	12821.	1.52
1842.1	4.45	1.31	12.34	2.88	12604.	1.60
1842.2	4.45	1.32	12.41	2.78	13303.	1.52
1843.1	5.04	1.02	12.85	2.83	13065.	1.47
1843.2	5.04	1.17	12.86	2.58	12549.	1.43
1941.1	5.87	1.19	12.47	2.50	12549.	1.31
1941.2	5.87	0.98	13.00	2.30	12600.	1.42
1941.3	5.87	0.98	13.00	2.48	12600.	1.35

A.4 R&F COAL COMPANY - DAILY, WEEKLY, MONTHLY COMPOSITE DATA

ROM COAL

CLEAN COAL

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR
134.1	4.34	0.55	23.76	3.18	10758.	1.89	2.69	12332.	1.09
134.2	4.34	0.55	23.97	3.18	10759.	1.72	2.62	12334.	1.09
234.1	4.62	0.32	23.65	3.44	10865.	1.72	2.44	12439.	1.03
234.2	4.62	0.32	23.89	3.39	10864.	1.67	2.44	12497.	0.94
334.1	4.33	1.79	21.56	3.36	11055.	1.44	2.85	12428.	1.26
334.2	4.33	1.39	21.86	3.29	11093.	1.55	2.74	12155.	1.44
434.1	3.21	2.82	21.58	3.14	10899.	1.72	2.76	12166.	1.32
434.2	3.21	2.86	21.82	3.16	10812.	1.72	1.97	12339.	1.32
500.0	0.00	0.00	0.00	0.00	0.00	0.00	2.11	12180.	1.15
500.0	0.00	0.00	0.00	0.00	0.00	0.00	2.67	12617.	1.49
634.1	5.09	0.56	20.34	3.06	11325.	1.78	2.57	12720.	1.38
634.2	5.09	0.74	19.53	2.97	11174.	1.72	0.00	0.00	0.00
700.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
700.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
800.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
800.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
900.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
900.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1000.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1000.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1100.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1100.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1200.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1200.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1300.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1300.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1334.1	6.62	1.07	20.30	3.23	11443.	1.95	2.78	12886.	1.37
1334.2	6.62	1.04	20.30	3.18	11424.	1.95	2.71	12872.	1.42
1434.1	14.30	0.79	23.15	3.33	11016.	1.92	2.52	12588.	1.26
1434.2	14.30	0.89	23.33	3.28	11128.	2.01	2.55	12464.	1.26
1500.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1500.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1600.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1600.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1734.1	5.79	0.93	22.94	3.18	11165.	1.30	2.65	12594.	1.31
1734.2	5.79	1.67	23.01	3.14	11344.	1.31	2.52	12806.	1.41
1834.1	5.13	0.41	22.66	3.82	11294.	1.67	2.70	12690.	1.49
1834.2	5.13	0.61	22.38	3.63	11066.	2.53	2.76	12796.	1.42

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/Lb	Pyritic Sulfur
15.0	5.27	2.60	22.30	3.31	10,752.0	1.69
25.0	5.24	2.19	19.81	3.15	10,982.0	1.98
55.0	6.39	0.61	21.50	3.75	11,303.0	1.64
65.0	6.47	0.96	22.18	3.01	11,338.0	1.83

WEEKLY

MONTHLY

A.5 R&F COAL COMPANY, IN-HOUSE ANALYTICAL DATA, CLEAN COAL

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	TOTAL SULFUR	ASH	TOTAL MOISTURE	RESIDUAL MOISTURE	PYRITIC SULFUR	BTU/LB	PYRITIC SULFUR
422 0030	10.97		14.08	2.74	12454.		2.57	13.38	6.42			12595.	
422 0100	11.52		14.41	2.62	12366.		2.69	12.77	6.25			12762.	
422 0130	7.88		13.80	2.53	12437.		2.70	12.67	5.96			12714.	
422 0200	8.62		13.64	2.44	12357.		2.40	12.64	6.10			12730.	
422 0230	7.88		13.65	2.43	12467.		2.58	14.20	8.02			13555.	
	0.00		0.00	0.00			2.47	13.75	7.51			12550.	
	0.00		0.00	0.00			2.57	13.40	7.49			12630.	
	0.00		0.00	0.00			2.75	14.48	11.71			12383.	
	0.00		0.00	0.00			0.00	0.00	0.00			0.	
	0.00		0.00	0.00			0.00	13.20	9.91			12729.	
	0.00		0.00	0.00			2.58	13.14	12.19			12631.	
	0.00		0.00	0.00			2.61	13.09	10.35			12581.	
	0.00		0.00	0.00			2.56	13.05	11.21			12595.	
	0.00		0.00	0.00			2.58	12.31	14.53			12720.	
	0.00		0.00	0.00			2.66	12.83	14.95			12642.	
	0.00		0.00	0.00			2.67	13.23	11.25			12571.	
	7.42		13.25	2.50	12465.		2.55	13.38	11.64			12596.	
422 0100	0.00		0.00	0.00			2.63	13.07	12.82			12604.	
	0.00		0.00	0.00			0.00	0.00	0.00			0.	
	0.22		14.06	2.48	12445.		0.00	0.00	0.00			0.	
422 0200	7.04		13.46	2.66	12506.		0.00	0.00	0.00			0.	
422 0230	7.05		13.50	2.64	12503.		0.00	0.00	0.00			0.	
422 0300	7.41		13.90	2.64	12501.		0.00	0.00	0.00			0.	
422 0400	7.07		13.26	2.64	12578.		0.00	0.00	0.00			0.	
422 0430	7.21		13.13	2.66	12107.		0.00	0.00	0.00			0.	
422 0500	7.52		13.50	2.45	12554.		0.00	0.00	0.00			0.	
422 0530	7.53		13.58	2.47	12498.		0.00	0.00	0.00			0.	
422 0600	7.42		13.35	2.50	12576.		0.00	0.00	0.00			0.	
422 0630	7.37		13.30	2.71	12417.		0.00	0.00	0.00			0.	
422 0700	8.09		14.01	2.78	12463.		0.00	0.00	0.00			0.	
422 0730	7.30		13.88	2.72	12436.		0.00	0.00	0.00			0.	
422 0800	7.63		13.39	2.74	12609.		0.00	0.00	0.00			0.	
422 0830	7.33		13.42	2.73	12556.		0.00	0.00	0.00			0.	
422 0900	7.58		13.66	2.70	12487.		0.00	0.00	0.00			0.	
422 0930	6.09		13.35	2.63	12577.		0.00	0.00	0.00			0.	
422 1000	7.70		13.21	2.60	12505.		0.00	0.00	0.00			0.	
422 1030	7.53		13.47	2.73	12455.		0.00	0.00	0.00			0.	
422 1100	7.48		13.65	2.73	12561.		0.00	0.00	0.00			0.	
422 1130	6.81		13.27	2.74	12643.		0.00	0.00	0.00			0.	
422 1200	7.88		13.52	2.72	12611.		0.00	0.00	0.00			0.	
423 0100	8.32		13.74	2.80	12532.		0.00	0.00	0.00			0.	
423 0130	7.78		13.45	2.81	12621.		0.00	0.00	0.00			0.	
423 0200	7.59		13.64	2.70	12519.		0.00	0.00	0.00			0.	
423 0230	7.50		13.88	2.65	12494.		0.00	0.00	0.00			0.	
423 0300	6.76		14.58	2.70	12424.		0.00	0.00	0.00			0.	
423 0330	7.31		13.65	2.67	12571.		0.00	0.00	0.00			0.	
423 0400	6.84		13.46	2.76	12585.		0.00	0.00	0.00			0.	
423 0430	7.06		14.34	2.82	12451.		0.00	0.00	0.00			0.	
423 0500	7.38		14.07	2.83	12455.		0.00	0.00	0.00			0.	
423 0530	7.38		13.94	2.50	12397.		0.00	0.00	0.00			0.	
423 0600	6.88		13.30	2.61	12430.		0.00	0.00	0.00			0.	
423 0630	7.23		13.98	2.58	12430.		0.00	0.00	0.00			0.	
423 0700	6.72		14.07	2.67	12542.		0.00	0.00	0.00			0.	
423 0730	6.72		13.21	2.88	12591.		0.00	0.00	0.00			0.	
423 0800	6.36		13.20	2.88	12591.		0.00	0.00	0.00			0.	
423 0830	6.40		13.23	2.84	12614.		0.00	0.00	0.00			0.	
423 0900	6.40		12.01	2.77	12645.		0.00	0.00	0.00			0.	
423 0930	7.25		13.70	2.74	12576.		0.00	0.00	0.00			0.	
423 1000	11.43		13.11	2.30	12717.		0.00	0.00	0.00			0.	
423 1030	7.37		13.70	2.54	12508.		0.00	0.00	0.00			0.	
423 1200	6.63		13.24	2.42	12618.		0.00	0.00	0.00			0.	

NOTE: Sample Code = Date Time (Hrs)

A.5 R&F COAL COMPANY, IN-HOUSE ANALYTICAL DATA, CLEAN COAL (Continued)

S	SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR
	424 0600	8.47	12.78	12.78	2.76	12752.	0.00	430 1230	7.43	0.00	13.83	2.44	12479.	0.00
	424 0630	9.49	13.09	13.09	2.75	12635.	0.00	430 0200	0.00	0.00	0.00	0.00	0.00	0.00
	424 0700	0.00	0.00	0.00	2.86	12590.	0.00	430 0230	7.15	0.00	12.47	2.56	12688.	0.00
	424 0800	9.57	13.31	13.31	0.00	12724.	0.00	430 0300	7.21	0.00	12.63	2.57	12645.	0.00
	424 0830	7.70	13.27	13.27	2.80	12615.	0.00	430 0330	7.18	0.00	13.24	2.49	12668.	0.00
	425 0400	8.17	13.70	13.70	2.84	12644.	0.00	430 0400	7.02	0.00	13.73	2.45	12459.	0.00
	425 0430	7.76	13.92	13.92	2.51	12555.	0.00	430 0430	6.76	0.00	13.82	2.51	12504.	0.00
	425 0500	7.71	13.99	13.99	2.41	12553.	0.00	430 0500	6.21	0.00	13.76	2.52	12466.	0.00
	425 0530	7.91	14.46	14.46	2.39	12464.	0.00	430 0530	6.20	0.00	13.85	2.46	12472.	0.00
	425 0600	7.99	14.85	14.85	2.35	12444.	0.00	430 0600	0.00	0.00	14.89	2.37	12309.	0.00
	425 0630	7.88	13.80	13.80	2.50	12601.	0.00	430 0630	0.00	0.00	14.36	2.35	12422.	0.00
	425 0700	6.89	13.86	13.86	2.83	12578.	0.00	430 0700	6.93	0.00	14.22	2.27	12427.	0.00
	425 0730	6.04	12.80	12.80	2.96	12747.	0.00	430 0730	7.44	0.00	14.60	2.37	12246.	0.00
	425 1100	0.00	0.00	0.00	0.00	12781.	0.00	430 0800	6.97	0.00	13.38	2.44	12477.	0.00
	425 1130	6.35	12.73	12.73	3.15	12500.	0.00	430 0830	10.25	0.00	13.50	2.39	12466.	0.00
	425 1200	7.66	13.78	13.78	2.75	12590.	0.00	430 0900	7.15	0.00	13.23	2.66	12515.	0.00
	425 1230	6.51	13.90	13.90	2.75	12535.	0.00	430 0930	7.24	0.00	13.26	2.45	12555.	0.00
	425 0100	7.16	14.47	14.47	2.82	12435.	0.00	430 1000	5.70	0.00	14.09	2.50	12425.	0.00
	425 0130	6.92	14.43	14.43	2.66	12489.	0.00	430 1100	0.00	0.00	14.52	2.36	12287.	0.00
	425 0200	6.49	14.54	14.54	2.82	12461.	0.00	430 1200	7.89	0.00	14.68	2.45	12322.	0.00
	425 0230	7.51	14.31	14.31	2.63	12478.	0.00	430 0100	8.38	0.00	13.74	0.00	0.00	0.00
	425 0300	6.22	13.33	13.33	2.55	12595.	0.00	430 0130	0.00	0.00	13.67	2.35	12448.	0.00
	425 0330	7.08	14.66	14.66	2.58	12362.	0.00	430 0200	11.45	0.00	13.82	2.36	12475.	0.00
	425 0400	9.83	14.08	14.08	2.67	12475.	0.00	430 0230	0.00	0.00	0.00	2.49	12427.	0.00
	425 0430	7.30	13.98	13.98	2.67	12517.	0.00	430 0300	0.00	0.00	0.00	0.00	0.00	0.00
	425 0500	7.42	14.34	14.34	2.54	12497.	0.00	430 0330	7.86	0.00	14.34	2.45	0.00	0.00
	425 0530	6.04	13.57	13.57	2.77	12621.	0.00	430 0400	0.00	0.00	13.14	2.46	0.00	0.00
	425 0600	12.78	14.42	14.42	2.76	12392.	0.00	430 0430	0.00	0.00	13.08	2.55	1249.	0.00
	429 0900	0.00	0.00	0.00	0.00	12443.	0.00	430 0500	0.00	0.00	13.14	2.61	12529.	0.00
	429 0930	23.02	14.77	14.77	2.41	12342.	0.00	430 0530	7.08	0.00	13.14	2.61	12529.	0.00
	429 1000	11.12	15.41	15.41	2.44	12333.	0.00	430 0600	7.81	0.00	13.08	2.61	12529.	0.00
	429 1030	10.85	15.20	15.20	2.30	12284.	0.00	430 0630	0.00	0.00	0.00	0.00	0.00	0.00
	429 1100	10.85	15.35	15.35	2.36	12359.	0.00	430 0700	7.32	0.00	12.84	2.63	12572.	0.00
	429 1130	12.06	14.73	14.73	2.51	12422.	0.00	430 0800	6.65	0.00	15.23	2.52	12197.	0.00
	429 1200	1.23	15.12	15.12	0.00	12399.	0.00	430 0830	7.03	0.00	13.03	2.75	12594.	0.00
	429 1230	8.71	14.88	14.88	2.42	12399.	0.00	430 0900	8.00	0.00	11.47	2.89	12835.	0.00
	429 0130	0.00	0.00	0.00	0.00	12334.	0.00	430 0930	8.80	0.00	10.93	2.43	12856.	0.00
	429 0200	7.26	15.37	15.37	2.32	12315.	0.00	430 1000	7.39	0.00	10.93	2.43	12856.	0.00
	429 0230	10.21	15.45	15.45	2.38	12304.	0.00	430 1100	0.00	0.00	12.79	2.53	12586.	0.00
	429 0300	8.97	15.41	15.41	2.35	12374.	0.00	501 1200	0.00	0.00	0.00	0.00	0.00	0.00
	429 0330	11.86	14.92	14.92	2.39	12374.	0.00	501 0130	7.35	0.00	13.62	2.49	12525.	0.00
	429 0400	8.62	15.13	15.13	2.41	12316.	0.00	501 0130	0.00	0.00	0.00	0.00	0.00	0.00
	429 0430	7.04	13.68	13.68	2.42	12340.	0.00	501 0230	7.04	0.00	13.60	2.61	12538.	0.00
	429 0500	7.55	13.22	13.22	2.49	12456.	0.00	501 0330	0.00	0.00	14.11	2.58	12434.	0.00
	429 0530	7.23	13.59	13.59	2.47	12488.	0.00	501 0430	7.28	0.00	14.56	2.33	12320.	0.00
	429 0600	6.00	13.63	13.63	2.56	12487.	0.00	501 0530	7.59	0.00	13.84	2.23	12425.	0.00
	429 0630	0.00	0.00	0.00	0.00	0.00	0.00	501 0630	0.00	0.00	0.00	0.00	0.00	0.00
	429 0700	0.00	0.00	0.00	0.00	0.00	0.00	501 0700	0.00	0.00	0.00	0.00	0.00	0.00
	429 0730	0.00	0.00	0.00	0.00	0.00	0.00	501 0800	0.00	0.00	0.00	0.00	0.00	0.00
	429 0800	0.00	0.00	0.00	0.00	0.00	0.00	501 0830	0.00	0.00	0.00	0.00	0.00	0.00
	429 0830	0.00	0.00	0.00	0.00	0.00	0.00	501 0900	0.00	0.00	0.00	0.00	0.00	0.00
	429 0900	0.00	0.00	0.00	0.00	0.00	0.00	501 0930	0.00	0.00	0.00	0.00	0.00	0.00
	429 0930	0.00	0.00	0.00	0.00	0.00	0.00	501 1000	0.00	0.00	0.00	0.00	0.00	0.00
	429 1000	0.00	0.00	0.00	0.00	0.00	0.00	501 1030	0.00	0.00	0.00	0.00	0.00	0.00
	429 1030	0.00	0.00	0.00	0.00	0.00	0.00	501 1100	0.00	0.00	0.00	0.00	0.00	0.00
	429 1100	0.00	0.00	0.00	0.00	0.00	0.00	501 1130	0.00	0.00	0.00	0.00	0.00	0.00
	429 1130	0.00	0.00	0.00	0.00	0.00	0.00	501 1200	0.00	0.00	0.00	0.00	0.00	0.00
	429 1200	0.00	0.00	0.00	0.00	0.00	0.00	501 1230	0.00	0.00	0.00	0.00	0.00	0.00
	429 1230	0.00	0.00	0.00	0.00	0.00	0.00	501 1300	0.00	0.00	0.00	0.00	0.00	0.00
	429 1300	0.00	0.00	0.00	0.00	0.00	0.00	501 1330	0.00	0.00	0.00	0.00	0.00	0.00
	429 1330	0.00	0.00	0.00	0.00	0.00	0.00	501 1400	0.00	0.00	0.00	0.00	0.00	0.00
	429 1400	0.00	0.00	0.00	0.00	0.00	0.00	501 1430	0.00	0.00	0.00	0.00	0.00	0.00
	429 1430	0.00	0.00	0.00	0.00	0.00	0.00	501 1500	0.00	0.00	0.00	0.00	0.00	0.00
	429 1500	0.00	0.00	0.00	0.00	0.00	0.00	501 1530	0.00	0.00	0.00	0.00	0.00	0.00
	429 1530	0.00	0.00	0.00	0.00	0.00	0.00	501 1600	0.00	0.00	0.00	0.00	0.00	0.00
	429 1600	0.00	0.00	0.00	0.00	0.00	0.00	501 1630	0.00	0.00	0.00	0.00	0.00	0.00

NOTE: Sample Code = Date Time (Hrs)

A.5 R&F COAL COMPANY, IN-HOUSE ANALYTICAL DATA, CLEAN COAL (Continued)

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR
501 1230	6.76	13.78	0.00	2.57	12449.	0.
501 0100	7.34	13.50	0.00	2.83	12598.	0.
501 0130	6.15	14.34	0.00	2.72	12466.	0.
501 0200	6.21	14.12	0.00	2.59	12471.	0.
501 0250	6.25	14.18	0.00	2.56	12502.	0.
501 0300	7.15	13.55	0.00	2.68	12530.	0.
501 0330	7.48	14.85	0.00	2.58	12448.	0.
501 0400	7.35	14.12	0.00	2.68	12461.	0.
501 0430	6.76	12.87	0.00	2.84	12752.	0.
501 0500	6.81	11.39	0.00	2.22	12954.	0.
501 0550	0.00	0.00	0.00	0.00	0.	0.
501 0600	7.62	11.30	0.00	2.20	12935.	0.
501 0700	6.57	10.90	0.00	2.35	12855.	0.
501 0730	5.98	11.36	0.00	2.16	12879.	0.
501 0800	8.57	11.10	0.00	3.03	12922.	0.
501 0830	6.87	10.88	0.00	3.01	13049.	0.
501 0900	7.70	11.15	0.00	2.87	13004.	0.
501 0930	7.08	11.41	0.00	2.86	12806.	0.
501 1000	7.08	10.58	0.00	2.98	13045.	0.
501 1030	6.81	10.77	0.00	2.95	13029.	0.
501 1100	6.00	11.85	0.00	2.69	12892.	0.
501 1130	7.19	13.30	0.00	2.57	12615.	0.
501 1200	7.78	13.54	0.00	2.53	12563.	0.
501 1230	6.79	13.57	0.00	2.68	12566.	0.
501 1260	7.17	13.54	0.00	2.71	12520.	0.
501 1290	6.68	13.82	0.00	2.60	12493.	0.
501 1300	6.00	13.43	0.00	2.63	12577.	0.
501 1330	7.44	14.20	0.00	2.64	12403.	0.
501 1400	7.40	13.91	0.00	2.57	12459.	0.
501 1430	7.00	13.91	0.00	2.44	12442.	0.
501 1500	6.93	13.90	0.00	2.59	12410.	0.
501 1530	7.17	14.62	0.00	2.56	12350.	0.
501 1600	6.73	14.20	0.00	2.56	12386.	0.
501 1630	6.98	14.31	0.00	2.46	12424.	0.
501 1700	0.00	0.00	0.00	0.00	0.	0.
501 1730	0.00	0.00	0.00	0.00	0.	0.
501 1800	6.78	14.16	0.00	2.46	12443.	0.
501 1830	6.00	0.00	0.00	0.00	0.	0.
501 1900	6.00	0.00	0.00	0.00	0.	0.
501 1930	6.88	14.64	0.00	2.54	12418.	0.
501 2000	7.13	14.85	0.00	2.57	12493.	0.
501 2030	7.26	14.17	0.00	2.62	12421.	0.
501 2100	7.00	14.70	0.00	2.66	12317.	0.
501 2130	6.68	15.26	0.00	2.58	12233.	0.
501 2200	6.00	14.00	0.00	2.66	12283.	0.
501 2230	6.00	0.00	0.00	0.00	0.	0.
501 2300	6.00	0.00	0.00	0.00	0.	0.
501 2330	6.00	0.00	0.00	0.00	0.	0.
501 2400	6.00	0.00	0.00	0.00	0.	0.
501 2430	6.00	0.00	0.00	0.00	0.	0.
501 2500	6.00	0.00	0.00	0.00	0.	0.
501 2530	6.00	0.00	0.00	0.00	0.	0.
501 2600	6.00	0.00	0.00	0.00	0.	0.
501 2630	6.00	0.00	0.00	0.00	0.	0.
501 2700	6.00	0.00	0.00	0.00	0.	0.
501 2730	6.00	0.00	0.00	0.00	0.	0.
501 2800	6.00	0.00	0.00	0.00	0.	0.
501 2830	6.00	0.00	0.00	0.00	0.	0.
501 2900	6.00	0.00	0.00	0.00	0.	0.
501 2930	6.00	0.00	0.00	0.00	0.	0.
501 3000	6.00	0.00	0.00	0.00	0.	0.
501 3030	6.00	0.00	0.00	0.00	0.	0.
501 3100	6.00	0.00	0.00	0.00	0.	0.
501 3130	6.00	0.00	0.00	0.00	0.	0.
501 3200	6.00	0.00	0.00	0.00	0.	0.
501 3230	6.00	0.00	0.00	0.00	0.	0.
501 3300	6.00	0.00	0.00	0.00	0.	0.
501 3330	6.00	0.00	0.00	0.00	0.	0.
501 3400	6.00	0.00	0.00	0.00	0.	0.
501 3430	6.00	0.00	0.00	0.00	0.	0.
501 3500	6.00	0.00	0.00	0.00	0.	0.
501 3530	6.00	0.00	0.00	0.00	0.	0.
501 3600	6.00	0.00	0.00	0.00	0.	0.
501 3630	6.00	0.00	0.00	0.00	0.	0.
501 3700	6.00	0.00	0.00	0.00	0.	0.
501 3730	6.00	0.00	0.00	0.00	0.	0.
501 3800	6.00	0.00	0.00	0.00	0.	0.
501 3830	6.00	0.00	0.00	0.00	0.	0.
501 3900	6.00	0.00	0.00	0.00	0.	0.
501 3930	6.00	0.00	0.00	0.00	0.	0.
501 4000	6.00	0.00	0.00	0.00	0.	0.
501 4030	6.00	0.00	0.00	0.00	0.	0.
501 4100	6.00	0.00	0.00	0.00	0.	0.
501 4130	6.00	0.00	0.00	0.00	0.	0.
501 4200	6.00	0.00	0.00	0.00	0.	0.
501 4230	6.00	0.00	0.00	0.00	0.	0.
501 4300	6.00	0.00	0.00	0.00	0.	0.
501 4330	6.00	0.00	0.00	0.00	0.	0.
501 4400	6.00	0.00	0.00	0.00	0.	0.
501 4430	6.00	0.00	0.00	0.00	0.	0.
501 4500	6.00	0.00	0.00	0.00	0.	0.
501 4530	6.00	0.00	0.00	0.00	0.	0.
501 4600	6.00	0.00	0.00	0.00	0.	0.
501 4630	6.00	0.00	0.00	0.00	0.	0.
501 4700	6.00	0.00	0.00	0.00	0.	0.
501 4730	6.00	0.00	0.00	0.00	0.	0.
501 4800	6.00	0.00	0.00	0.00	0.	0.
501 4830	6.00	0.00	0.00	0.00	0.	0.
501 4900	6.00	0.00	0.00	0.00	0.	0.
501 4930	6.00	0.00	0.00	0.00	0.	0.
501 5000	6.00	0.00	0.00	0.00	0.	0.
501 5030	6.00	0.00	0.00	0.00	0.	0.
501 5100	6.00	0.00	0.00	0.00	0.	0.
501 5130	6.00	0.00	0.00	0.00	0.	0.
501 5200	6.00	0.00	0.00	0.00	0.	0.
501 5230	6.00	0.00	0.00	0.00	0.	0.
501 5300	6.00	0.00	0.00	0.00	0.	0.
501 5330	6.00	0.00	0.00	0.00	0.	0.
501 5400	6.00	0.00	0.00	0.00	0.	0.
501 5430	6.00	0.00	0.00	0.00	0.	0.
501 5500	6.00	0.00	0.00	0.00	0.	0.
501 5530	6.00	0.00	0.00	0.00	0.	0.
501 5600	6.00	0.00	0.00	0.00	0.	0.
501 5630	6.00	0.00	0.00	0.00	0.	0.
501 5700	6.00	0.00	0.00	0.00	0.	0.
501 5730	6.00	0.00	0.00	0.00	0.	0.
501 5800	6.00	0.00	0.00	0.00	0.	0.
501 5830	6.00	0.00	0.00	0.00	0.	0.
501 5900	6.00	0.00	0.00	0.00	0.	0.
501 5930	6.00	0.00	0.00	0.00	0.	0.
501 6000	6.00	0.00	0.00	0.00	0.	0.
501 6030	6.00	0.00	0.00	0.00	0.	0.
501 6100	6.00	0.00	0.00	0.00	0.	0.
501 6130	6.00	0.00	0.00	0.00	0.	0.
501 6200	6.00	0.00	0.00	0.00	0.	0.
501 6230	6.00	0.00	0.00	0.00	0.	0.
501 6300	6.00	0.00	0.00	0.00	0.	0.
501 6330	6.00	0.00	0.00	0.00	0.	0.
501 6400	6.00	0.00	0.00	0.00	0.	0.
501 6430	6.00	0.00	0.00	0.00	0.	0.
501 6500	6.00	0.00	0.00	0.00	0.	0.
501 6530	6.00	0.00	0.00	0.00	0.	0.
501 6600	6.00	0.00	0.00	0.00	0.	0.
501 6630	6.00	0.00	0.00	0.00	0.	0.
501 6700	6.00	0.00	0.00	0.00	0.	0.
501 6730	6.00	0.00	0.00	0.00	0.	0.
501 6800	6.00	0.00	0.00	0.00	0.	0.
501 6830	6.00	0.00	0.00	0.00	0.	0.
501 6900	6.00	0.00	0.00	0.00	0.	0.
501 6930	6.00	0.00	0.00	0.00	0.	0.
501 7000	6.00	0.00	0.00	0.00	0.	0.
501 7030	6.00	0.00	0.00	0.00	0.	0.
501 7100	6.00	0.00	0.00	0.00	0.	0.
501 7130	6.00	0.00	0.00	0.00	0.	0.
501 7200	6.00	0.00	0.00	0.00	0.	0.
501 7230	6.00	0.00	0.00	0.00	0.	0.
501 7300	6.00	0.00	0.00	0.00	0.	0.
501 7330	6.00	0.00	0.00	0.00	0.	0.
501 7400	6.00	0.00	0.00	0.00	0.	0.
501 7430	6.00	0.00	0.00	0.00	0.	0.
501 7500	6.00	0.00	0.00	0.00	0.	0.
501 7530	6.00	0.00	0.00	0.00	0.	0.
501 7600	6.00	0.00	0.00	0.00	0.	0.
501 7630	6.00	0.00	0.00	0.00	0.	0.
501 7700	6.00	0.00	0.00	0.00	0.	0.
501 7730	6.00	0.00	0.00	0.00	0.	0.
501 7800	6.00	0.00	0.00	0.00	0.	0.
501 7830	6.00	0.00	0.00	0.00	0.	0.
501 7900	6.00	0.00	0.00	0.00	0.	0.
501 7930	6.00	0.00	0.00	0.00	0.	0.
501 8000	6.00	0.00	0.00	0.00	0.	0.
501 8030	6.00	0.00	0.00	0.00	0.	0.
501 8100	6.00	0.00	0.00	0.00	0.	0.
501 8130	6.00	0.00	0.00	0.00	0.	0.
501 8200	6.00	0.00	0.00	0.00	0.	0.
501 8230	6.00	0.00	0.00	0.00	0.	0.
501 8300	6.00	0.00	0.00	0.00	0.	0.
501 8330	6.00	0.00	0.00	0.00	0.	0.
501 8400	6.00	0.00	0.00	0.00	0.	0.
501 8430	6.00	0.00	0.00	0.00	0.	0.
501 8500	6.00	0.00	0.00	0.00	0.	0.
501 8530	6.00	0.00	0.00	0.00	0.	0.
501 8600	6.00	0.00	0.00	0.00	0.	0.
501 8630	6.00	0.00	0.00	0.00	0.	0.
501 8700	6.00	0.00	0.00	0.00	0.	0.
501 8730	6.00	0.00	0.00	0.00	0.	0.
501 8800	6.00	0.00	0.00	0.00	0.	0.
501 8830	6.00	0.00	0.00	0.00	0.	0.
501 8900	6.00	0.00	0.00	0.00	0.	0.
501 8930	6.00	0.00	0.00	0.00	0.	0.
501 9000	6.00	0.00	0.00	0.00	0.	0.
501 9030	6.00	0.00	0.00	0.00	0.	0.
501 9100	6.00	0.00	0.00	0.00	0.	0.
501 9130	6.00	0.00	0.00	0.00	0.	0.
501 9200	6.00	0.00	0.00	0.00	0.	0.
501 9230	6.00	0.00	0.00	0.00	0.	0.
501 9300</						

NOTE: Sample Code = Date Time (Hrs)

A.5 R&F COAL COMPANY, IN-HOUSE ANALYTICAL DATA, CLEAN COAL (Continued)

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR
515 1030	6.33	12.85	12.85	2.54	12638.	0	516 1330	7.58	12.28	12.61	12692.	12.61	
515 1100	6.22	12.22	12.22	2.77	12645.	0	516 1330	8.63	13.01	13.01	12542.	13.01	
515 1130	6.19	12.61	12.61	2.61	12687.	0	516 1400	7.54	13.95	13.95	12442.	13.95	
515 1200	7.58	13.12	13.12	2.79	12614.	0	516 1430	7.75	14.23	14.23	12384.	14.23	
515 1230	6.04	13.26	13.26	2.98	12556.	0	516 1500	7.92	14.27	14.27	12349.	14.27	
515 1300	5.96	12.84	12.84	2.70	12558.	0	516 1530	7.07	13.37	13.37	12480.	13.37	
515 1330	5.97	14.33	14.33	2.61	12433.	0	516 1600	7.33	13.29	13.29	12483.	13.29	
515 1330	0.00	0.00	0.00	0.00	0	0	516 1630	7.21	12.58	12.58	12483.	12.58	
515 1530	0.00	0.00	0.00	0.00	0	0	516 1700	7.04	12.46	12.46	12592.	12.46	
515 1530	5.85	11.81	11.81	2.98	12835.	0	516 1730	7.25	12.45	12.45	12623.	12.45	
515 1600	9.41	9.00	9.00	3.51	13252.	0	516 1800	6.95	13.42	13.42	12516.	13.42	
515 1600	9.41	9.00	9.00	0.00	13154.	0	516 1830	7.10	13.60	13.60	12571.	13.60	
515 1700	9.73	9.85	9.85	3.27	13154.	0	516 1900	6.73	13.90	13.90	12374.	13.90	
515 1700	0.00	0.00	0.00	0.00	0	0	516 2000	6.40	0.00	0.00	0	0	
515 1700	0.00	0.00	0.00	0.00	0	0	516 2030	6.49	14.72	14.72	12433.	14.72	
515 1700	0.00	0.00	0.00	0.00	0	0	516 2100	6.32	14.33	14.33	12502.	14.33	
515 1700	0.00	0.00	0.00	0.00	0	0	516 2130	6.17	14.82	14.82	12577.	14.82	
515 1700	0.00	0.00	0.00	0.00	0	0	516 2200	6.13	14.54	14.54	12552.	14.54	
515 1700	0.00	0.00	0.00	0.00	0	0	516 2230	6.13	14.60	14.60	12327.	14.60	
515 1700	0.00	0.00	0.00	0.00	0	0	519 0000	6.29	14.26	14.26	12608.	14.26	
515 1700	0.00	0.00	0.00	0.00	0	0	519 0045	6.20	13.39	13.39	12434.	13.39	
515 1700	0.00	0.00	0.00	0.00	0	0	519 0130	6.32	14.29	14.29	12656.	14.29	
515 1700	0.00	0.00	0.00	0.00	0	0	519 0300	6.63	0.00	0.00	0	0	
515 1700	0.00	0.00	0.00	0.00	0	0	519 0330	7.37	18.21	18.21	11883.	18.21	
515 1700	0.00	0.00	0.00	0.00	0	0	519 0400	7.32	12.69	12.69	12559.	12.69	
515 1700	0.00	0.00	0.00	0.00	0	0	519 0430	6.95	14.57	14.57	12435.	14.57	
515 1700	0.00	0.00	0.00	0.00	0	0	519 0500	6.96	14.18	14.18	12458.	14.18	
515 1700	0.00	0.00	0.00	0.00	0	0	519 1030	7.09	14.45	14.45	12349.	14.45	
515 1700	0.00	0.00	0.00	0.00	0	0	519 1100	9.95	13.71	13.71	12490.	13.71	
515 1700	0.00	0.00	0.00	0.00	0	0	519 1130	6.74	13.39	13.39	12496.	13.39	
515 1700	0.00	0.00	0.00	0.00	0	0	519 1200	6.75	13.50	13.50	12526.	13.50	
515 1700	6.89	13.71	13.71	2.58	12510.	0	519 1230	5.80	14.21	14.21	12550.	14.21	
515 1700	7.26	12.61	12.61	2.61	12620.	0	519 1300	5.88	12.93	12.93	12464.	12.93	
515 1700	5.51	14.71	14.71	2.51	12376.	0	519 1330	6.40	12.63	12.63	12435.	12.63	
515 1700	6.14	15.95	15.95	2.28	12268.	0	519 1400	6.50	12.63	12.63	12650.	12.63	
515 1700	5.81	15.08	15.08	2.40	12537.	0	519 1430	6.48	12.08	12.08	12650.	12.08	
515 1700	5.69	14.88	14.88	2.52	12371.	0	519 1500	6.54	12.12	12.12	12665.	12.12	
515 1700	5.81	14.31	14.31	2.48	12300.	0	519 1530	6.97	13.42	13.42	12520.	13.42	
515 1700	5.80	15.39	15.39	2.39	12361.	0	519 1600	6.18	12.89	12.89	12663.	12.89	
515 1700	5.59	16.66	16.66	3.88	12680.	0	519 1630	6.18	12.37	12.37	12663.	12.37	
515 1700	5.56	15.53	15.53	3.48	13200.	0	519 1700	7.27	12.52	12.52	12643.	12.52	
515 1700	5.72	13.81	13.81	3.20	13181.	0	519 1730	6.91	11.92	11.92	12737.	11.92	
515 1700	7.88	9.67	9.67	3.11	13255.	0	519 1800	6.91	10.98	10.98	12846.	10.98	
515 1700	7.01	9.67	9.67	3.07	13163.	0	519 1830	7.28	9.76	9.76	12846.	9.76	
515 1700	6.60	9.47	9.47	3.16	13210.	0	519 1900	6.76	11.13	11.13	13024.	11.13	
515 1700	6.76	9.73	9.73	3.12	13249.	0	519 1930	6.77	11.97	11.97	12676.	11.97	
515 1700	5.97	9.73	9.73	2.93	13340.	0	519 2000	6.76	12.00	12.00	12676.	12.00	
515 1700	6.69	9.50	9.50	2.96	13415.	0	519 2030	6.77	12.13	12.13	12676.	12.13	
515 1700	6.01	9.31	9.31	2.88	13201.	0	519 2100	6.70	12.65	12.65	12676.	12.65	
515 1700	5.54	9.31	9.31	2.88	13201.	0	519 2130	6.72	11.98	11.98	12686.	11.98	
515 1700	5.63	9.50	9.50	3.04	13217.	0	519 2200	6.75	12.05	12.05	12821.	12.05	
515 1700	5.63	9.53	9.53	3.04	13171.	0	519 2230	6.72	12.00	12.00	12778.	12.00	
515 1700	5.34	9.25	9.25	2.72	13160.	0	519 2300	6.53	12.01	12.01	12766.	12.01	
515 1700	5.34	9.53	9.53	2.72	13160.	0	520 0000	6.75	12.27	12.27	12766.	12.27	
515 1700	7.22	1.06	1.06	3.73	12841.	0	520 0030	6.75	12.27	12.27	12766.	12.27	
515 1700	7.53	1.95	1.95	3.00	12041.	0	520 0030	6.75	12.27	12.27	12766.	12.27	
515 1700	7.53	1.13	1.13	2.65	12060.	0	520 0030	6.75	12.27	12.27	12766.	12.27	
515 1700	7.53	1.53	1.53	2.65	12060.	0	520 0030	6.75	12.27	12.27	12766.	12.27	
515 1700	7.81	12.10	12.10	2.47	12023.	0	520 0030	6.75	12.27	12.27	12766.	12.27	

NOTE: Sample Code = Date Time (Hrs)

A.5 R&F COAL COMPANY, IN-HOUSE ANALYTICAL DATA, CLEW COAL (Continued)

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR
520 0100	6.72		11.62	2.72	12836.		522 1600	5.57		13.86	2.45	12536.	
520 0130	6.66		12.26	2.58	12681.		522 1630	5.75		13.04	2.42	12636.	
520 0200	6.73		12.10	2.50	12817.		522 1700	5.35		14.68	2.34	12383.	
			0.00	0.00	0.		522 1730	5.32		14.16	2.58	12470.	
520 0300	6.39		11.37	2.76	12860.		522 1800	6.23		12.99	2.50	12559.	
520 0330	6.28		12.30	2.70	12709.		522 1830	5.75		13.41	2.37	12611.	
520 0400	6.23		12.67	2.83	12739.		522 1900	6.04		13.62	2.40	12518.	
520 0430	5.92		13.17	2.51	12491.		522 1930	7.07		13.06	2.33	12549.	
520 0500	5.45		11.48	2.76	12873.		522 2000	6.80		13.68	2.26	12329.	
520 0530	5.60		10.24	3.10	13187.		522 2030	6.86		13.39	2.30	12396.	
520 0600	5.88		9.47	3.05	13316.		522 2100	7.19		13.13	2.30	12448.	
520 0630	6.03		10.16	3.04	13116.		522 2200	7.09		0.00	0.00	0.	
520 0700	5.58		10.26	3.00	13074.		522 2300	6.78		13.23	2.33	12411.	
	0.00		0.00	0.00	0.		523 0001	7.00		0.00	0.00	0.	
520 0800	9.52		10.21	3.31	13068.		523 0100	6.98		13.77	2.26	12422.	
	0.00		0.00	0.00	0.		523 0130	6.99		0.00	0.00	0.	
520 0930	6.10		10.99	3.07	12946.		523 0230	6.99		13.57	2.36	12508.	
520 1000	5.55		11.87	3.02	12852.		523 0300	6.98		0.00	0.00	0.	
520 1030	6.53		12.11	3.05	12862.		523 0330	6.69		13.60	2.35	12706.	
520 1100	6.34		12.05	3.17	12810.		523 0400	6.69		13.59	2.41	12534.	
520 1130	7.08		11.45	3.03	12810.		523 0500	6.99		0.00	0.00	0.	
520 1200	6.41		13.14	2.30	12590.		523 0600	7.40		14.07	2.31	12467.	
520 1230	6.95		13.61	2.30	12588.		523 0630	7.25		13.61	2.52	12422.	
520 1300	6.91		13.33	2.30	12663.		523 0700	6.19		13.47	2.43	12495.	
	0.00		0.00	0.00	0.		523 0730	21.52		13.24	2.27	12495.	
520 1400	6.67		12.38	2.64	12775.		523 0800	6.80		13.44	2.23	12476.	
520 1430	6.66		14.25	2.56	12404.		523 0900	6.26		0.00	0.00	0.	
520 1500	6.49		12.81	3.49	12788.		523 0930	6.64		13.38	2.40	12530.	
520 1530	6.51		12.38	3.21	12819.		523 1000	6.19		12.72	2.53	12642.	
520 1600	7.33		12.80	2.64	12769.		523 1030	6.00		13.80	2.36	12565.	
520 1630	7.17		11.44	2.90	12916.		523 1100	6.82		0.00	0.00	0.	
520 1700	6.25		11.24	2.89	12927.		523 1130	8.72		13.58	2.17	12426.	
520 1730	7.49		11.20	3.21	12911.		523 1200	6.21		13.59	2.31	12507.	
520 1800	6.37		11.17	3.00	13141.		523 1230	6.34		13.45	2.43	12369.	
520 1830	6.75		9.06	3.15	13051.		523 1300	6.82		12.85	2.68	12626.	
520 1900	6.53		12.63	2.58	12712.		523 1330	8.16		12.38	2.48	12639.	
	0.00		0.00	0.00	0.		523 1400	8.38		11.82	2.44	12773.	
520 2030	6.94		11.01	2.97	12963.		523 1430	7.74		11.71	2.38	12802.	
522 0630	4.31		12.80	2.42	12623.		523 1500	7.79		11.89	2.38	12789.	
	0.00		0.00	0.00	0.		523 1530	6.91		11.54	2.33	12803.	
522 0800	7.15		13.61	2.42	12519.		523 1600	7.62		11.41	2.32	12833.	
522 0830	6.46		13.12	2.37	12600.		523 1630	7.59		11.55	2.37	12827.	
522 0900	5.92		13.81	2.20	12486.		523 1700	7.16		11.35	2.36	12839.	
	0.00		0.00	0.00	0.		523 1730	7.48		12.76	2.34	12605.	
522 1030	6.42		13.24	2.30	12685.		523 1800	11.35		13.80	2.50	12611.	
522 1100	8.54		12.06	2.50	12655.		523 1830	8.61		13.54	2.52	12598.	
522 1130	6.38		12.00	2.44	12433.		523 1900	7.72		14.20	2.63	12459.	
522 1200	5.23		14.53	2.58	12200.		523 1930	6.91		13.64	2.56	12555.	
522 1230	5.20		15.78	2.20	12401.		523 2000	10.64		14.82	2.55	12540.	
522 1300	5.30		14.47	2.35	12401.		523 2030	6.39		13.55	2.72	12573.	
522 1400	5.18		14.34	2.45	12638.		523 2100	6.56		13.80	2.77	12563.	
522 1430	5.41		15.11	2.45	12324.		523 2130	6.58		13.81	2.85	12520.	
522 1500	5.87		14.68	2.20	12352.		523 2200	6.73		13.44	2.94	12621.	
522 1530	6.07		14.85	2.22	12367.		523 2230	6.46		12.73	2.92	12762.	
523 0001	7.00		15.46	2.32	12194.		523 2300	5.73		12.60	2.76	12761.	
							523 2330	5.86		13.46	2.63	12778.	
							523 2400	6.28		12.82	2.75	12736.	

SAMPLE TO

NOTE: Sample Code = Date Time (Hrs)

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PHYRITIC SULFUR
521	1.00	0.55	12.48	2.70	12754.	
522	1.30	0.93	11.66	2.68	12881.	
523	1.00	0.96	11.58	2.66	12932.	
524	1.30	0.95	11.14	2.89	12817.	
525	1.00	0.90	11.57	2.65	12808.	
526	1.30	0.94	12.65	2.72	12764.	
527	1.00	0.80	0.00	0.00	0.	
528	0.00	0.00	0.00	0.00	0.	
529	0.00	0.00	0.00	0.00	0.	
530	0.00	0.00	0.00	0.00	0.	
531	0.00	0.00	0.00	0.00	0.	
532	0.00	0.00	0.00	0.00	0.	
533	0.00	0.00	0.00	0.00	0.	
534	0.00	0.00	0.00	0.00	0.	
535	0.00	0.00	0.00	0.00	0.	
536	0.00	0.00	0.00	0.00	0.	
537	0.00	0.00	0.00	0.00	0.	
538	0.00	0.00	0.00	0.00	0.	
539	0.00	0.00	0.00	0.00	0.	
540	0.00	0.00	0.00	0.00	0.	
541	0.00	0.00	0.00	0.00	0.	
542	0.00	0.00	0.00	0.00	0.	
543	0.00	0.00	0.00	0.00	0.	
544	0.00	0.00	0.00	0.00	0.	
545	0.00	0.00	0.00	0.00	0.	
546	0.00	0.00	0.00	0.00	0.	
547	0.00	0.00	0.00	0.00	0.	
548	0.00	0.00	0.00	0.00	0.	
549	0.00	0.00	0.00	0.00	0.	
550	0.00	0.00	0.00	0.00	0.	
551	0.00	0.00	0.00	0.00	0.	
552	0.00	0.00	0.00	0.00	0.	
553	0.00	0.00	0.00	0.00	0.	
554	0.00	0.00	0.00	0.00	0.	
555	0.00	0.00	0.00	0.00	0.	
556	0.00	0.00	0.00	0.00	0.	
557	0.00	0.00	0.00	0.00	0.	
558	0.00	0.00	0.00	0.00	0.	
559	0.00	0.00	0.00	0.00	0.	
560	0.00	0.00	0.00	0.00	0.	
561	0.00	0.00	0.00	0.00	0.	
562	0.00	0.00	0.00	0.00	0.	
563	0.00	0.00	0.00	0.00	0.	
564	0.00	0.00	0.00	0.00	0.	
565	0.00	0.00	0.00	0.00	0.	
566	0.00	0.00	0.00	0.00	0.	
567	0.00	0.00	0.00	0.00	0.	
568	0.00	0.00	0.00	0.00	0.	
569	0.00	0.00	0.00	0.00	0.	
570	0.00	0.00	0.00	0.00	0.	
571	0.00	0.00	0.00	0.00	0.	
572	0.00	0.00	0.00	0.00	0.	
573	0.00	0.00	0.00	0.00	0.	
574	0.00	0.00	0.00	0.00	0.	
575	0.00	0.00	0.00	0.00	0.	
576	0.00	0.00	0.00	0.00	0.	
577	0.00	0.00	0.00	0.00	0.	
578	0.00	0.00	0.00	0.00	0.	
579	0.00	0.00	0.00	0.00	0.	
580	0.00	0.00	0.00	0.00	0.	
581	0.00	0.00	0.00	0.00	0.	
582	0.00	0.00	0.00	0.00	0.	
583	0.00	0.00	0.00	0.00	0.	
584	0.00	0.00	0.00	0.00	0.	
585	0.00	0.00	0.00	0.00	0.	
586	0.00	0.00	0.00	0.00	0.	
587	0.00	0.00	0.00	0.00	0.	
588</						

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A.5 R&F COAL COMPANY, IN-HOUSE ANALYTICAL DATA, CLEAN COAL (Continued)

SAMPLE CODE	TOTAL RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	SAMPLE CODE	TOTAL RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR
602 1000	0.00	0.00	0.00	0.00	0.00	603 1530	6.05	13.73	2.46	12498.	0.00
602 1030	0.56	0.00	0.00	0.00	0.00	603 1630	5.70	13.79	2.39	12471.	0.00
602 1060	7.36	14.84	2.38	12399.	0.00	603 1700	6.53	12.55	2.31	12688.	0.00
602 1100	6.99	14.60	2.39	12313.	0.00	603 1730	6.84	12.55	2.31	12688.	0.00
602 1130	6.27	14.93	2.51	12392.	0.00	603 1800	6.93	12.67	2.40	12741.	0.00
602 1200	6.42	14.26	2.55	12302.	0.00	603 1830	7.00	13.64	2.23	12447.	0.00
602 1300	6.17	13.78	2.68	12304.	0.00	603 1900	7.88	13.14	2.31	12482.	0.00
602 1330	6.16	14.18	2.68	12501.	0.00	603 1930	7.16	13.21	2.34	12553.	0.00
602 1400	12.03	13.81	2.87	12459.	0.00	603 2000	7.01	12.77	2.40	12629.	0.00
602 1430	5.80	13.16	2.75	12594.	0.00	603 2100	6.97	13.51	2.38	12471.	0.00
602 1500	5.96	9.51	3.35	13205.	0.00	603 2130	7.51	13.72	2.24	12385.	0.00
602 1530	5.88	8.67	3.84	13270.	0.00	603 2200	6.76	14.02	2.20	12398.	0.00
602 1600	5.96	10.52	3.03	12999.	0.00	603 2300	6.07	13.03	2.58	12578.	0.00
602 1630	6.21	12.92	2.74	12656.	0.00	603 2330	7.34	13.08	2.53	12613.	0.00
602 1700	6.15	12.10	2.69	12724.	0.00	603 2400	6.86	9.42	3.06	13252.	0.00
602 1800	6.55	14.07	2.49	12374.	0.00	604 0030	6.99	13.68	2.40	12581.	0.00
602 1830	6.98	13.21	2.47	12519.	0.00	604 0100	6.63	13.18	2.23	12634.	0.00
602 1900	7.78	14.29	2.46	12472.	0.00	604 0130	6.63	13.32	2.31	12590.	0.00
602 1930	6.67	13.96	2.42	12507.	0.00	604 0200	6.00	13.31	2.52	12600.	0.00
602 2000	6.63	14.05	2.34	12459.	0.00	604 0330	6.78	0.00	0.00	0.00	0.00
602 2100	6.92	13.70	2.51	12546.	0.00	604 0430	6.67	11.40	2.79	12918.	0.00
602 2130	6.46	14.38	2.10	12394.	0.00	604 0530	7.17	0.00	0.00	0.00	0.00
602 2200	5.71	12.88	2.82	12634.	0.00	604 0630	0.00	10.90	2.68	12918.	0.00
602 2230	5.69	12.48	2.91	12743.	0.00	604 0730	7.27	0.00	0.00	0.00	0.00
602 2300	7.29	12.72	2.83	12760.	0.00	604 0800	6.99	11.21	2.64	12967.	0.00
602 2330	6.66	8.77	3.00	13203.	0.00	604 0900	6.47	0.00	0.00	0.00	0.00
603 0030	6.63	9.00	0.00	13227.	0.00	604 1000	6.44	10.96	2.66	12962.	0.00
603 0100	7.02	9.76	2.85	13279.	0.00	604 1030	5.81	10.54	2.76	13053.	0.00
603 0200	6.00	9.02	2.90	12889.	0.00	604 1100	5.58	11.01	2.70	12965.	0.00
603 0230	6.37	11.39	2.92	12899.	0.00	604 1200	5.52	0.00	0.00	0.00	0.00
603 0300	6.56	12.74	2.65	12640.	0.00	604 1300	6.11	10.21	2.80	13110.	0.00
603 0330	6.31	13.50	2.42	12561.	0.00	604 1400	5.90	9.38	2.28	13225.	0.00
603 0400	6.25	13.60	2.55	12515.	0.00	604 1500	5.77	8.64	2.5	13363.	0.00
603 0430	5.84	13.12	2.63	12530.	0.00	604 1600	5.46	12.00	2.5	13438.	0.00
603 0500	6.32	11.89	2.80	12780.	0.00	604 1700	6.36	8.40	0.00	0.00	0.00
603 0530	6.39	12.97	2.35	12618.	0.00	604 1800	7.56	14.09	0.00	0.00	0.00
603 0600	6.67	13.88	2.54	12475.	0.00	604 1900	7.96	0.00	0.00	0.00	0.00
603 0630	6.35	12.97	2.75	12726.	0.00	604 2000	6.66	13.88	2.41	12525.	0.00
603 0700	6.50	13.70	2.44	12564.	0.00	604 2100	6.22	14.27	2.41	12549.	0.00
603 0730	6.36	13.58	2.47	12485.	0.00	604 2200	6.22	14.37	2.55	12483.	0.00
603 0800	6.73	14.00	2.54	12484.	0.00	604 2300	6.58	0.00	0.00	0.00	0.00
603 0830	6.00	12.57	2.72	12670.	0.00	604 2400	6.58	0.00	0.00	0.00	0.00
603 0900	6.05	0.00	0.00	12670.	0.00	604 2500	6.58	13.80	2.34	12390.	0.00
603 0930	6.12	13.51	2.55	12610.	0.00	604 2600	6.58	14.44	2.46	12484.	0.00
603 1000	6.40	13.90	2.43	12610.	0.00	604 2700	6.58	14.46	2.43	12435.	0.00
603 1030	6.30	13.35	2.55	12520.	0.00	604 2800	6.58	14.31	2.50	12425.	0.00
603 1100	28.41	14.07	2.80	12306.	0.00	604 2900	6.58	13.59	2.51	12579.	0.00
603 1130	11.66	13.88	2.60	12441.	0.00	604 3000	6.58	0.00	0.00	0.00	0.00
603 1200	6.33	13.82	2.63	12463.	0.00	604 3100	6.58	13.12	2.55	12741.	0.00
603 1230	6.79	13.00	2.76	12546.	0.00	604 3200	6.58	13.29	2.52	12619.	0.00
603 1300	6.02	13.04	2.67	12591.	0.00	604 3300	6.58	13.25	2.59	12571.	0.00
603 1330	6.21	12.69	2.61	12708.	0.00	604 3400	6.58	11.01	2.83	12994.	0.00
603 1400	5.95	12.95	2.77	12655.	0.00	604 3500	6.58	10.35	2.83	13105.	0.00
603 1430	5.68	12.30	2.84	12829.	0.00	604 3600	6.58	0.00	0.00	0.00	0.00
603 1500	5.84	13.80	2.67	12485.	0.00	604 3700	6.58	7.12	3.30	13638.	0.00
603 1530	5.84	12.80	2.67	12507.	0.00	604 3800	6.58	0.00	0.00	0.00	0.00

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NOTE: Sample Code = Date Time (Hrs)

A.5 R&F COAL COMPANY, IN-HOUSE ANALYTICAL DATA, CLEAN COAL, (Continued)

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	ASH BTU/LB	PYRITIC SULFUR	SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	ASH BTU/LB	PYRITIC SULFUR
604 2200	6.41	7.41	3.24	13514.	606 0300	6.79	606 0300	6.79	12708.	12.76	2.85	12708.	
604 2230	6.49	7.35	3.20	13551.	606 0330	6.42	606 0330	6.42	12814.	11.78	3.13	12814.	
604 2300	6.96	7.55	3.20	13530.	606 0400	6.45	606 0400	6.45	12705.	13.27	2.86	12705.	
604 2330	6.96	7.65	3.15	13511.	606 0430	6.10	606 0430	6.10	12903.	11.67	2.97	12903.	
604 2400	7.11	13.18	2.48	12643.	606 0500	6.45	606 0500	6.45	12918.	11.90	3.17	12918.	
605 0000	6.23	8.22	3.34	13432.	606 0530	7.09	606 0530	7.09	12756.	12.19	2.84	12756.	
605 0030	6.76	13.04	2.41	12729.	606 0600	6.63	606 0600	6.63	12747.	12.14	2.92	12747.	
605 0100	7.05	13.11	2.31	12681.	606 0630	-1.00	606 0630	-1.00	13012.	10.87	3.05	13012.	
605 0130	7.07	14.09	2.24	12487.					-1.00	-1.00			
605 0200	6.55	14.73	2.32	12415.									
605 0230	6.38	14.72	2.24	12345.									
605 0300	6.31	15.04	2.29	12358.									
	0.00	0.00	0.00	0.00									
	0.00	0.00	0.00	0.00									
	0.00	0.00	0.00	0.00									
	0.00	0.00	0.00	0.00									
605 0530	6.52	13.05	2.62	12837.									
605 0600	7.62	10.47	2.67	12967.									
605 0630	7.77	11.04	2.68	12963.									
605 0700	8.04	11.25	2.88	12901.									
	0.00	0.00	0.00	0.00									
605 0800	8.54	10.22	2.90	13077.									
	0.00	0.00	0.00	0.00									
605 0900	8.28	13.21	2.46	12659.									
605 0930	7.53	13.61	2.41	12645.									
	0.00	0.00	0.00	0.00									
	0.00	0.00	0.00	0.00									
605 1100	7.74	13.29	2.43	12663.									
605 1130	8.40	12.98	2.38	12630.									
	0.00	0.00	0.00	0.00									
	0.00	0.00	0.00	0.00									
	0.00	0.00	0.00	0.00									
	0.00	0.00	0.00	0.00									
605 1400	7.54	13.50	2.53	12645.									
605 1430	7.35	13.73	2.69	12544.									
	0.00	0.00	0.00	0.00									
	0.00	0.00	0.00	0.00									
	0.00	0.00	0.00	0.00									
	0.00	0.00	0.00	0.00									
	0.00	0.00	0.00	0.00									
	0.00	0.00	0.00	0.00									
605 1830	12.68	0.00	0.00	0.00									
605 1900	11.43	12.48	2.68	12730.									
605 1930	8.31	11.08	2.78	12883.									
605 2000	8.10	10.63	2.89	12948.									
605 2030	8.47	10.77	2.94	13028.									
605 2100	8.68	10.26	2.30	13181.									
	0.00	0.00	0.00	0.00									
605 2200	8.76	10.78	2.04	12928.									
605 2230	8.21	10.85	2.81	12973.									
605 2300	7.35	10.79	2.83	13040.									
605 2330	8.32	10.76	2.99	13073.									
606 0000	8.31	11.40	3.16	12950.									
606 0030	8.20	12.10	3.02	12940.									
606 0100	7.90	11.02	2.89	12862.									
606 0130	7.22	12.70	2.77	12854.									
606 0200	7.00	12.03	2.96	12788.									
606 0230	6.53	11.85	2.96	12890.									

NOTE: Sample Code = Date Time (Hrs)

A.6 REPUBLIC STEEL CORPORATION - HOURLY AND HALF-HOUR INCREMENTAL DATA, ROM COAL.

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	TONS/HR	DATE	TIME
213011	3.88	0.72	27.25	2.94	10904.	1.85	430	21	900
213012	3.88	0.70	27.08	2.95	10887.	1.73	950	21	1000
213031	0.00	0.00	0.00	0.00	0.	0.00			
213051	5.42	0.77	30.43	2.59	10330.	1.54	890	21	1100
213071	5.19	0.85	30.74	2.70	10202.	1.67	910	21	1200
213091	5.93	0.89	34.84	2.21	9525.	1.46			
213091	5.59	0.87	35.45	2.28	9576.	1.42	940	21	1300
213111	5.23	0.75	34.09	2.24	9713.	1.35			
223011	5.06	0.66	33.73	2.19	9471.	1.41	490	21	1400
223011	5.06	0.87	28.03	2.19	10780.	1.28	770	22	800
223031	4.55	0.47	31.07	2.53	9996.	1.57	990	22	900
223051	4.55	0.47	31.08	2.55	10143.	1.47			
223071	4.10	0.48	31.56	2.37	10169.	1.54	960	22	1000
223071	4.62	0.57	31.11	2.33	10162.	1.27			
223091	4.62	0.45	35.23	2.47	9546.	1.59	950	22	1100
223111	4.16	0.43	35.17	2.32	9511.	1.35			
223131	3.57	0.45	27.44	2.15	10830.	1.22	975	22	1200
223131	4.16	0.60	26.80	2.57	10805.	1.27	490	22	1300
223131	4.16	0.21	30.43	2.34	10897.	1.64			
223131	0.00	0.40	0.00	0.00	10889.	1.62			
223131	0.00	0.00	0.00	0.00	10358.	1.49			
223131	0.00	0.00	0.00	0.00	10345.	1.36			
223131	6.91	0.90	29.84	2.72	0.	0.00	0	22	1400
233031	4.65	0.93	29.71	2.75	10795.	1.70	970	23	830
233051	5.24	0.54	27.84	3.04	10795.	1.50	990	23	930
233071	5.24	0.65	27.34	2.99	10801.	1.88			
233071	5.24	0.37	24.84	2.63	10863.	1.85	990	23	1030
233071	5.24	0.56	26.70	2.44	11033.	1.57			
233091	4.73	0.48	30.31	2.69	11033.	1.55	960	23	1130
233091	4.73	0.61	30.29	2.69	10323.	1.57			
233111	4.87	0.52	32.06	2.44	10329.	1.64	950	23	1230
233111	4.87	0.56	32.15	2.42	10018.	1.24			
233131	4.87	0.44	40.68	2.72	10073.	1.43	960	23	1330
233131	4.87	0.43	40.41	2.69	8616.	1.49			
233131	6.58	0.40	26.71	2.60	8599.	1.45	960	23	1430
243011	4.89	0.42	26.22	2.91	10948.	1.57	885	24	800
243031	4.78	0.55	37.36	2.84	10949.	1.67			
243031	4.78	0.52	36.66	2.91	9147.	1.60	910	24	900
243051	4.65	0.96	26.64	3.06	9147.	1.71			
243071	4.65	0.81	26.58	3.01	10723.	1.68	890	24	1000
243071	0.00	0.97	33.74	2.90	10975.	1.93			
243071	0.00	0.97	33.40	2.90	9555.	1.76	460	24	1100
243091	0.00	0.00	0.00	0.00	9700.	1.90			
243091	0.00	0.00	0.00	0.00	0.	0.00			
243111	4.26	0.00	0.00	0.00	0.	0.00	0	24	1200
243131	3.60	0.00	0.00	0.00	0.	0.00	900	24	1300
243131	3.60	1.00	47.26	1.88	7580.	1.10	440	24	1400
243131	3.60	1.01	47.40	1.94	7649.	1.10			
243131	3.60	1.08	38.26	2.21	8908.	1.35			
243131	3.60	1.07	38.87	2.16	8997.	1.22			

A.6 REPUBLIC STEEL CORPORATION - HOURLY AND HALF-HOUR INCREMENTAL DATA, ROM COAL (Continued)

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	TONS/HR	DATE	TIME
253011	3.78	0.37	27.96	2.58	10624.	1.46	900	25	800
253012	3.78	0.40	27.84	2.43	10717.	1.49			
253031	4.84	0.47	28.50	2.79	10716.	1.59	860	25	900
253051	4.84	0.55	28.50	2.72	10674.	1.56			
253051	4.91	0.63	28.01	2.60	8895.	1.54	890	25	1000
253071	4.91	0.78	27.55	2.60	8906.	1.49			
253071	3.94	0.74	26.34	2.40	9283.	1.44	870	25	1100
253091	3.94	0.59	26.09	2.49	9283.	1.49			
253091	4.26	0.57	25.11	2.76	11147.	1.75	890	25	1200
253111	4.26	0.52	25.06	2.80	11186.	1.72			
253111	3.99	0.54	24.15	2.61	11223.	1.56	950	25	1300
253131	3.99	0.53	24.62	2.60	11236.	1.54			
253131	6.09	0.62	27.32	2.77	10731.	1.84	890	25	1400
253131	6.09	0.57	27.65	3.72	10659.	1.63			
263011	3.84	0.25	28.77	3.06	10672.	1.97	430	28	930
263021	3.84	0.28	28.64	3.15	10272.	1.87			
263021	4.11	0.25	27.28	2.92	10873.	1.70	430	28	1000
263021	4.11	0.19	27.48	2.83	10896.	1.64			
263031	4.54	0.31	27.74	3.03	10655.	1.98	870	28	1030
263031	4.54	0.24	28.14	3.10	10763.	2.10			
263041	4.44	0.42	46.72	2.80	7841.	1.77	870	28	1130
263041	4.44	0.36	46.50	2.99	7897.	1.67			
263051	3.30	0.61	30.33	2.49	10390.	1.52	480	28	1200
263051	3.30	0.41	31.08	2.34	10407.	1.46			
263061	4.20	0.26	31.62	2.46	10281.	1.66	920	28	1230
263071	4.20	0.51	31.82	2.51	10255.	1.64			
263071	4.37	0.37	35.07	2.35	9452.	1.64	890	28	1300
263081	4.37	0.39	36.19	2.35	9650.	1.63			
263081	4.08	0.58	36.62	2.60	8974.	1.66	930	28	1330
263091	4.24	0.44	37.54	2.62	8879.	1.75			
263091	4.24	0.38	33.52	2.62	9897.	1.57	910	28	1400
263101	4.16	0.32	30.11	2.51	9868.	1.63			
263101	4.16	0.32	30.11	2.88	10522.	1.96	900	28	1430
263111	4.16	0.45	30.37	2.85	10485.	1.73			
263111	4.16	0.31	31.10	2.39	10363.	1.44	910	28	1500
273011	4.16	0.50	31.78	2.44	10369.	1.47			
273011	4.26	0.56	28.14	2.74	10283.	1.54	920	29	800
273021	4.26	0.60	28.18	2.75	10614.	1.72			
273021	5.59	0.61	33.92	2.90	9836.	1.71	960	29	830
273031	5.59	0.58	33.44	3.00	9753.	1.89			
273031	5.23	0.58	37.28	2.67	9100.	1.58	900	29	900
273041	5.23	0.56	37.37	2.71	9100.	1.63			
273041	3.56	0.60	34.16	2.26	9634.	1.52	900	29	930
273051	3.56	0.63	34.20	2.26	9634.	1.76			
273051	4.00	0.59	37.09	2.17	9210.	1.23	980	29	1000
273061	4.00	0.53	37.47	2.18	9138.	1.29			
273061	5.27	0.62	27.24	2.78	10883.	1.79	850	29	1030
273071	5.27	0.70	26.89	2.60	10831.	1.61			
273071	4.07	1.07	30.23	2.56	8897.	1.75	850	29	1100
273081	4.07	0.72	30.04	2.62	8859.	1.74			
273081	3.63	0.60	24.57	2.51	11341.	1.72	910	29	1130
273091	3.63	0.62	24.32	2.62	11341.	1.93			
273091	3.38	0.67	43.30	2.62	8852.	1.94	970	29	1200
273091	3.38	0.68	42.92	2.64	8891.	2.01			

A.6 REPUBLIC STEEL CORPORATION - HOURLY AND HALF-HOUR INCREMENTAL DATA, ROM COAL (Continued)

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	TONS/HR	DATE	TIME
273101	4.68	0.63	33.53	2.14	9954.	1.34	990	29	1230
273102	4.68	0.61	32.83	2.00	9925.	1.48			
273111	4.37	0.46	28.84	2.55	10636.	1.43	440	29	1300
273121	4.85	0.92	28.80	2.51	10610.	1.56			
273131	4.85	0.91	28.21	2.58	10752.	1.74	915	29	1330
273141	4.46	0.85	33.77	2.49	10657.	1.72	780	29	1400
273151	4.86	0.65	31.30	2.53	9549.	1.65			
273161	4.86	0.66	31.46	2.51	9426.	1.48	950	29	1430
273171	0.00	0.00	0.00	0.00	10100.	1.71			
273181	0.00	0.00	0.00	0.00	0.	0.00	0	0	1500
283011	5.27	0.64	34.32	2.07	9789.	1.30	400	30	800
283021	4.70	0.57	34.90	2.04	9709.	1.25			
283031	4.23	0.51	30.64	3.15	9470.	2.09	860	30	830
283041	3.76	0.50	33.35	2.57	9498.	2.15	880	30	900
283051	4.13	0.48	26.72	2.50	10324.	1.38			
283061	4.14	0.59	41.53	2.23	10325.	1.58	950	30	930
283071	3.65	0.44	32.68	2.23	9830.	1.34			
283081	2.59	0.51	29.94	2.23	9797.	1.50	840	30	1000
283091	3.49	0.53	36.81	2.06	10874.	1.79			
283101	4.61	0.92	37.75	2.81	10888.	1.79	850	30	1030
283111	4.08	0.89	38.31	2.30	8473.	1.32			
283121	5.30	0.96	35.38	2.30	8377.	1.22	860	30	1100
283131	5.02	0.91	29.53	2.28	9845.	1.30			
283141	4.50	0.76	33.99	2.50	9878.	1.46	880	30	1130
283151	5.66	0.45	31.64	2.49	10538.	1.61			
293011	4.39	0.49	31.31	2.08	9347.	1.41	830	30	1200
293021	4.79	0.98	35.84	2.14	9222.	1.39			
293031	3.64	0.86	27.96	2.21	9055.	1.27	850	30	1230
293041	7.21	0.39	30.30	2.21	9050.	1.24			
293051	3.82	0.72	31.49	2.22	9298.	1.57	950	30	1300
293061	3.70	0.54	36.34	2.66	9298.	1.62			
				2.73	10329.	1.57	920	30	1330
				2.69	10420.	1.86			
				2.37	9613.	1.51	950	30	1400
				2.49	9595.	1.50			
				2.33	10114.	1.44	720	30	1430
				2.33	10074.	1.57			
				2.57	10240.	1.62	0	30	1500
				2.76	10210.	1.60			
				2.80	10478.	1.80	730	31	800
				2.56	9464.	1.80			
				2.86	10722.	1.80	830	31	830
				3.00	10756.	1.90	900	31	900
				2.36	9620.	1.83			
				2.65	9850.	1.71	980	31	930
				2.40	9828.	1.59			
				2.44	9828.	1.59	870	31	1000
				2.87	9383.	1.77			
				2.80	9233.	1.77	910	31	1030

A.6 REPUBLIC STEEL CORPORATION - HOURLY AND HALF-HOUR INCREMENTAL DATA, ROM COAL (Continued)

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PVRITIC SULFUR	TONS/HR	DATE	TIME
293071	4.49	0.75	48.37	3.39	7271.	1.75	860	31	1100
293081	4.49	0.67	48.40	2.47	7233.	1.77			
293091	4.34	0.49	31.75	2.53	9981.	1.75	890	31	1130
293101	5.94	0.46	27.97	2.53	10176.	1.69			
293111	5.94	0.54	27.71	2.47	10763.	1.73	940	31	1200
293121	5.76	0.49	28.05	2.28	10638.	1.79			
293131	5.76	0.54	28.46	3.11	10095.	2.03	500	31	1230
293141	5.77	0.52	28.92	3.13	10096.	1.91			
293151	4.77	0.52	35.04	2.97	9377.	1.66	920	31	1300
293161	4.77	0.52	35.48	2.97	9461.	1.56			
293171	4.39	0.41	31.55	2.62	9712.	1.48	950	31	1330
293181	4.39	0.49	31.81	2.62	9712.	1.54			
293191	5.50	0.44	27.20	2.07	10835.	1.76	900	31	1400
293201	5.50	0.51	27.93	2.11	10845.	1.65			
293211	4.57	0.76	40.48	2.86	8659.	1.15	950	31	1430
293221	4.57	0.93	40.38	2.86	8460.	1.10			
293231	4.57	0.68	30.68	3.19	10093.	1.22	840	31	1500
293241	4.57	0.73	31.00	3.02	10235.	1.30			
293251	3.26	0.63	35.41	2.47	9487.	1.50	420	1	830
293261	3.26	0.74	35.06	2.54	9424.	1.51			
293271	0.00	0.00	0.00	0.00	0.00	0.00	0	1	900
293281	0.00	0.00	0.00	0.00	0.00	0.00	0	1	930
293291	0.00	0.00	0.00	0.00	0.00	0.00	0	1	930
293301	0.00	0.00	0.00	0.00	0.00	0.00	0	1	930
293311	0.00	0.00	0.00	0.00	0.00	0.00	0	1	930
293321	0.00	0.00	0.00	0.00	0.00	0.00	0	1	930
293331	0.00	0.00	0.00	0.00	0.00	0.00	0	1	930
293341	4.24	1.68	27.99	2.76	10514.	1.87	870	1	1000
293351	4.24	0.73	28.86	2.63	10482.	1.80			
293361	4.91	1.06	26.37	2.69	10660.	1.53	900	1	1030
293371	4.91	1.43	26.30	2.72	10660.	1.74			
293381	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293391	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293401	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293411	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293421	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293431	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293441	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293451	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293461	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293471	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293481	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293491	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293501	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293511	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293521	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293531	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293541	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293551	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293561	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293571	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293581	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293591	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293601	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293611	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293621	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293631	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293641	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293651	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293661	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293671	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293681	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293691	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293701	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293711	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293721	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293731	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293741	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293751	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293761	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293771	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293781	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293791	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293801	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293811	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293821	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293831	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293841	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293851	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293861	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293871	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293881	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293891	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293901	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293911	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293921	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293931	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293941	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293951	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293961	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293971	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293981	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
293991	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294001	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294011	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294021	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294031	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294041	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294051	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294061	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294071	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294081	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294091	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294101	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294111	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294121	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294131	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294141	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294151	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294161	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294171	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294181	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294191	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294201	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294211	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294221	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294231	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294241	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294251	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294261	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294271	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294281	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294291	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294301	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294311	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294321	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294331	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294341	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294351	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294361	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294371	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294381	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294391	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294401	0.00	0.00	0.00	0.00	0.00	0.00	0	1	1100
294411	0.00	0.00	0.00						

A.6 REPUBLIC STEEL CORPORATION - HOURLY AND HALF-HOUR INCREMENTAL DATA, ROM COAL (Continued)

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	TONS/HR	DATE	TIME
313061	5.96	0.44	30.31	2.64	10373.	1.52	880	5	1230
2	5.96	0.45	30.26	2.82	10373.	1.77			
313071	3.99	0.34	27.67	2.73	10756.	1.91	900	5	1300
2	3.99	0.40	28.10	2.73	10732.	1.82			
313081	5.01	0.32	32.39	2.69	9910.	1.63	860	5	1330
2	5.01	0.36	32.19	2.69	9976.	1.52			
313091	4.40	0.51	32.33	2.72	9872.	1.46	840	5	1400
2	4.40	0.53	32.28	2.81	9872.	1.47			
313101	4.33	0.43	39.48	2.37	8856.	1.41	830	5	1430
2	4.33	0.51	39.57	2.27	8692.	1.36			
313111	4.01	0.43	26.20	2.85	10877.	1.39	840	5	1500
2	4.01	0.38	26.10	2.71	10395.	1.39			
323011	4.36	0.24	30.50	2.91	10304.	1.54	1000	6	830
2	4.36	0.22	31.58	2.88	10102.	1.63			
323021	4.75	0.19	35.40	2.33	9715.	1.50	930	6	900
2	4.75	0.18	35.49	2.45	9666.	1.38			
323031	4.29	0.23	31.61	2.32	10073.	1.27	1150	6	930
2	4.29	0.20	31.46	2.34	10081.	1.35			
323041	4.20	0.50	38.49	2.67	8859.	1.68	1180	6	1000
2	4.20	0.46	38.71	2.67	8879.	1.67			
323051	3.74	0.49	36.34	3.04	9363.	1.87	870	6	1030
2	3.74	0.56	36.36	3.05	9363.	1.87			
323061	4.57	0.57	35.79	2.43	9707.	1.39	910	6	1100
2	4.57	0.45	35.79	2.53	9707.	1.46			
323071	5.16	0.39	30.08	2.83	10435.	1.68	950	6	1130
2	5.16	0.43	30.08	2.73	10398.	1.74			
323081	4.54	0.58	36.16	3.07	9388.	1.84	890	6	1200
2	4.54	0.61	36.46	2.88	9331.	1.95			
323091	4.53	0.64	37.50	2.18	9231.	1.33	450	6	1230
2	4.53	0.65	36.76	2.33	9168.	1.30			
323101	3.98	0.42	27.24	2.80	10599.	1.61	810	6	1300
2	3.98	0.46	27.66	2.80	10774.	1.67			
323111	4.83	0.73	33.07	2.75	9947.	1.54	850	6	1330
2	4.83	0.87	33.57	2.70	9824.	1.68			
323121	3.66	0.58	43.36	2.22	8182.	1.02	940	6	1400
2	3.66	0.59	43.11	2.22	8077.	0.97			
323131	4.16	0.55	26.88	2.81	10820.	1.59	800	6	1430
2	4.16	0.56	26.86	2.62	10820.	1.62			
323141	4.21	0.61	28.60	3.06	9437.	1.81	840	6	1500
2	4.21	0.55	28.60	2.98	9297.	1.74			
333011	4.09	0.72	24.19	2.57	11380.	1.40	950	7	800
2	4.09	0.64	24.14	2.45	11353.	1.51			
333021	5.40	0.70	31.04	2.76	10238.	1.66	1180	7	830
2	5.40	0.54	30.99	2.73	10136.	1.70			
333031	3.91	0.71	31.74	3.00	10185.	1.93	1100	7	900
2	3.91	0.69	31.19	3.07	10162.	2.01			
333041	5.82	0.70	27.95	2.80	10807.	1.87	1170	7	930
2	5.82	0.84	27.95	2.85	10807.	1.67			
333051	4.26	1.01	30.14	2.51	10391.	1.58	1160	7	1000
2	4.26	0.83	30.11	2.64	10384.	1.66			
333061	5.15	0.93	26.46	2.75	10950.	1.75	930	7	1030
2	5.15	0.61	26.46	2.65	10976.	1.81			
333071	4.51	1.12	31.70	2.41	10154.	1.61	950	7	1100
2	4.51	0.65	31.54	2.50	10116.	1.51			

A.6 REPUBLIC STEEL CORPORATION - HOURLY AND HALF-HOUR INCREMENTAL DATA, ROM COAL (Continued)

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	TONS/HR	DATE	TIME
333081	4.38	0.69	40.19	2.79	7557.	1.84	800	7	1130
333091	4.38	0.69	40.51	2.92	7557.	1.72	440	7	1200
333101	0.00	0.00	0.00	0.00	0.	0.00	940	7	1230
333111	3.92	0.63	37.49	2.44	8570.	1.61	880	7	1300
333121	3.48	0.64	27.67	2.30	10770.	1.32	0	7	1330
333131	0.00	0.00	0.00	0.00	10854.	1.27	880	7	1400
333141	4.30	0.78	28.89	2.39	0.	0.00	900	7	1430
333151	3.17	0.53	26.64	2.19	10165.	1.47	450	8	830
343011	3.95	0.92	36.93	2.11	10278.	1.46	860	8	900
343021	4.74	0.87	36.90	2.09	10916.	1.28	780	8	930
343031	5.64	1.10	34.73	2.53	10918.	1.44	1000	8	1000
343041	5.07	0.79	31.14	2.63	9317.	1.34	970	8	1030
343051	4.36	0.72	28.33	2.66	9479.	1.50	920	8	1100
343061	4.63	0.54	28.64	2.59	9850.	1.59	1000	8	1130
343071	3.56	0.43	34.45	2.35	10060.	1.75	940	8	1200
343081	4.86	0.65	27.26	3.06	10588.	1.68	920	8	1230
343091	4.48	0.55	26.34	3.10	10651.	1.76	640	8	1300
343101	4.54	0.85	28.91	2.72	9676.	1.80	820	8	1330
343111	4.84	1.41	36.00	2.54	9698.	1.84	460	8	1400
343121	4.56	1.57	28.73	3.15	10934.	1.43	960	8	1430
343131	5.25	1.35	33.00	2.70	10934.	1.75	480	11	200
343141	4.97	1.76	28.23	2.52	9940.	1.41	550	11	1100
343151	4.68	1.70	28.38	2.62	10482.	1.39	0	11	1200
353011	4.97	2.23	29.07	2.66	10509.	1.40	0	11	1300
353021	4.68	0.47	29.09	2.85	1076.	1.41	0	11	1400
353031	5.35	0.50	30.50	2.82	10109.	1.67	830	11	1500
353041	0.00	0.49	30.63	2.75	10498.	1.49	500	11	1500
353051	0.00	0.00	0.00	0.00	10540.	1.56	0	11	1500
353061	0.00	0.00	0.00	0.00	10275.	0.00	0	11	1500
353071	0.00	0.00	0.00	0.00	0.	0.00	0	11	1500
353081	0.00	0.00	0.00	0.00	0.	0.00	0	11	1500
353091	0.00	0.00	0.00	0.00	0.	0.00	0	11	1500
353101	0.00	0.00	0.00	0.00	0.	0.00	0	11	1500
353111	0.00	0.00	0.00	0.00	0.	0.00	0	11	1500
353121	5.76	0.46	36.08	2.68	9330.	1.31	830	11	1500
353131	5.76	0.38	35.22	2.58	9462.	1.41	500	11	1500
353141	0.00	0.00	0.00	0.00	0.	0.00	0	11	1500
353151	0.00	0.00	0.00	0.00	0.	0.00	0	11	1500

A.6 REPUBLIC STEEL CORPORATION - HOURLY AND HALF-HOUR INCREMENTAL DATA, ROM COAL (Continued)

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	TONS/HR	DATE	TIME
363011	5.52	2.10	34.37	2.69	8716.	1.63	460	12	800
363031	5.52	1.97	34.22	2.84	8905.	1.56	0	12	900
363051	6.00	0.00	0.00	0.00	0.	0.00	0	12	1000
363071	6.34	1.75	41.51	2.62	8113.	1.44	870	12	1100
363091	5.75	1.85	41.73	2.60	8183.	1.48	890	12	1200
363111	5.75	1.43	41.03	2.45	8114.	1.28	700	12	1300
363131	4.65	1.52	40.97	2.42	8181.	1.27	950	12	1400
363151	4.65	1.01	28.26	2.43	10586.	1.34	910	12	1500
363171	6.40	0.65	34.69	2.65	9572.	1.40	800	14	1000
363191	6.35	0.32	34.50	2.67	9556.	1.55	800	14	1100
363211	6.35	0.78	33.63	2.87	9685.	1.76	800	14	1200
363231	3.92	0.87	33.63	2.84	9680.	1.46	800	14	1300
363251	3.92	0.70	37.19	2.82	10880.	1.42	800	14	1400
363271	19.07	0.61	27.05	2.87	10830.	1.77	800	14	1500
363291	10.07	0.60	26.04	2.81	10830.	1.80	800	14	1600
363311	5.90	0.65	26.07	2.80	11084.	1.45	800	14	1700
363331	5.90	0.64	32.77	2.51	11100.	1.63	800	14	1800
363351	5.90	0.61	32.29	2.55	10111.	1.51	800	14	1900
363371	4.92	0.55	31.40	2.53	10079.	1.63	800	14	2000
363391	4.92	0.92	31.10	2.45	10253.	1.38	800	14	2100
363411	4.70	0.93	37.62	2.31	9160.	1.43	800	14	2200
363431	4.70	0.68	38.16	2.24	9160.	1.38	800	14	2300
363451	3.73	0.97	46.53	1.86	9160.	1.36	800	14	2400
363471	3.73	1.04	45.70	1.86	7595.	1.63	800	14	2500
363491	0.00	0.00	0.00	0.00	0.	1.00	800	14	2600
363511	0.00	0.00	0.00	0.00	0.	0.00	800	14	2700
363531	5.63	0.95	31.59	2.43	10056.	0.00	800	14	2800
363551	5.63	0.92	31.80	2.41	10073.	1.43	800	14	2900
363571	5.27	0.62	36.06	2.35	9213.	1.50	800	14	3000
363591	5.27	0.85	35.95	2.29	9355.	1.50	800	14	3100
363611	5.05	0.49	28.12	2.20	10550.	1.41	800	14	3200
363631	5.05	0.91	28.12	2.85	10550.	1.56	800	14	3300
363651	4.63	0.90	32.76	2.44	9190.	1.67	800	14	3400
363671	4.63	0.82	32.38	2.28	9357.	1.42	800	14	3500
363691	3.72	0.75	26.50	2.54	11033.	1.40	800	14	3600
363711	3.72	0.72	26.08	2.56	11033.	1.44	800	14	3700
363731	5.60	0.72	33.03	2.22	11067.	1.53	800	14	3800
363751	5.60	0.72	32.54	2.22	11049.	1.42	800	14	3900
363771	2.38	0.72	50.79	2.29	10960.	1.44	800	14	4000
363791	2.38	0.74	51.35	1.18	6912.	1.44	800	14	4100
363811	5.75	0.58	32.71	1.20	6806.	0.71	800	14	4200
363831	5.75	0.61	33.24	2.11	10037.	1.55	800	14	4300
363851	4.80	0.54	33.24	2.10	9937.	1.46	800	14	4400
363871	4.80	0.60	24.01	2.71	11336.	1.62	800	14	4500
363891	4.10	0.64	26.45	2.70	11336.	1.58	800	14	4600
363911	5.15	0.74	25.43	2.68	10982.	1.75	800	14	4700
363931	5.15	0.90	25.46	2.65	10985.	1.75	800	14	4800
363951	4.90	0.81	24.82	2.48	11152.	1.75	800	14	4900
363971	4.90	0.77	32.36	2.34	11179.	1.70	800	14	5000
363991	5.28	1.01	27.52	2.38	9979.	1.23	800	14	5100
364011	5.28	1.01	27.67	2.57	10768.	1.56	800	14	5200
364031	5.28	1.12	27.75	2.57	10768.	1.64	800	14	5300
364051	5.28	1.12	27.75	2.57	10768.	1.57	800	14	5400

A.6 REPUBLIC STEEL CORPORATION - HOURLY AND HALF-HOUR INCREMENTAL DATA, ROM COAL (Continued)

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	TONS/HR	DATE	TIME
393071	3.91	0.93	31.19	2.45	10644.	1.46	690	15	1100
393091	5.74	1.03	32.46	2.31	10644.	1.44	720	15	1200
393111	9.33	0.92	32.48	2.50	9919.	1.57	800	15	1300
393131	6.31	0.77	33.61	2.19	9737.	1.49	850	15	1400
393151	3.39	0.71	26.97	3.36	10056.	2.27	640	15	1500
	3.39	0.54	20.82	2.38	11128.	1.46			
		0.55	20.78	2.21	11239.	1.46			

STOP

END OF EXECUTION
CPU TIME: 4.71 ELAPSED TIME: 24:31.37
EXIT

A.6 REPUBLIC STEEL CORPORATION - HOURLY AND HALF-HOUR INCREMENTAL DATA, CLEMI COAL

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	TONS/HR	DATE	TIME
214091	7.65	0.76	12.07	1.35	13410.	0.64	500	21	1300
214111	7.65	0.83	11.78	1.31	13460.	0.68	570	21	1400
224011	9.69	0.39	9.64	1.33	13743.	0.62	450	22	830
224031	6.61	0.47	9.62	1.24	13866.	0.61	600	22	930
224051	7.71	0.30	9.29	1.36	13896.	0.63	620	22	1030
224071	7.71	0.33	9.32	1.47	13934.	0.58	600	22	1130
224091	7.71	0.35	9.48	1.33	13866.	0.56	600	22	1230
224111	7.71	0.35	9.58	1.53	13916.	0.63	600	22	1330
224131	9.03	0.29	10.01	1.51	13862.	0.63	600	22	1430
234011	9.03	0.12	10.59	1.49	13837.	0.66	600	23	800
234031	10.48	0.12	10.91	1.40	13716.	0.52	600	23	900
234051	10.48	0.07	10.98	1.36	13735.	0.52	600	23	1000
234071	7.05	0.25	10.30	1.28	13818.	0.69	580	23	1100
234091	7.05	0.17	10.79	1.45	13662.	0.74	570	23	1200
234111	6.44	0.11	10.84	1.34	14022.	0.68	550	23	1300
234131	6.44	0.15	10.77	1.40	13638.	0.67	560	23	1400
234151	0.00	0.00	0.00	0.00	0.	0.00	580	23	1500
234171	0.00	0.00	0.00	0.00	0.	0.00	360	24	830
234191	8.71	0.29	8.85	1.30	13959.	0.54	580	24	930
234211	8.71	0.48	9.28	1.30	13984.	0.51	530	24	1030
234231	6.89	0.20	9.50	1.42	13858.	0.62	560	24	1130
234251	6.89	0.49	9.37	1.40	13858.	0.59	580	24	1230
234271	5.88	0.50	9.48	1.35	13949.	0.58	570	24	1330
234291	5.88	0.29	9.42	1.33	13949.	0.68	550	24	1430
234311	7.40	0.49	9.00	1.44	13944.	0.57	560	24	1530
234331	7.40	0.18	8.97	1.43	13981.	0.53	580	24	1630
234351	10.59	0.81	9.59	1.34	13938.	0.52	580	24	1730
234371	10.59	0.32	9.82	1.30	13778.	0.49	580	24	1830
234391	7.43	0.34	9.14	1.32	13851.	0.57	360	24	1930
234411	6.26	0.65	9.55	1.41	13849.	0.52	580	24	2030
234431	6.26	0.53	9.56	1.40	13788.	0.53	580	24	2130
234451	7.29	0.88	9.05	1.21	13980.	0.48	530	24	2230
234471	7.29	0.89	9.25	1.31	13915.	0.58	530	24	2330
234491	8.15	0.64	9.76	1.33	13765.	0.54	530	24	2430
234511	8.15	0.54	9.70	1.31	13887.	0.47	530	24	2530
234531	9.39	0.94	8.18	1.23	14089.	0.54	530	24	2630
234551	9.39	0.93	8.73	1.21	14113.	0.61	530	24	2730
234571	6.85	0.55	8.86	1.27	13662.	0.55	530	24	2830
234591	6.85	0.43	9.00	1.51	13844.	0.54	530	24	2930
234611	7.91	0.68	8.30	1.29	13866.	0.50	530	24	3030
234631	7.91	0.56	8.88	1.28	14080.	0.50	530	24	3130
234651	6.84	0.38	9.03	1.26	14080.	0.51	530	24	3230
234671	6.84	0.40	8.84	1.31	14013.	0.51	530	24	3330
234691	7.69	0.46	8.83	1.32	14153.	0.55	530	24	3430
234711	7.69	0.39	8.83	1.27	13537.	0.62	530	24	3530
234731	10.40	2.15	9.90	1.42	13537.	0.58	530	24	3630
234751	10.40	2.31	9.94	1.35	13655.	0.52	530	24	3730
234771	6.51	0.16	9.24	1.48	13724.	0.49	530	24	3830
234791	6.51	0.30	8.45	1.25	13724.	0.51	530	24	3930
234811	7.73	2.39	8.73	1.35	13651.	0.51	530	24	4030
234831	6.16	1.74	8.73	1.18	13907.	0.47	530	24	4130
234851	6.16	1.82	9.00	1.37	13907.	0.47	530	24	4230

A.6 REPUBLIC STEEL CORPORATION - HOURLY AND HALF-HOUR INCREMENTAL DATA, CLEAN COAL (Cont.)

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	TONS/HR	DATE	TIME
254091	7.60	1.51	8.85	1.23	13840.	0.51	560	25	1230
254111	7.60	1.54	8.68	1.37	13840.	0.52	570	25	1330
254131	8.50	0.89	9.56	1.24	13924.	0.52	490	25	1430
254151	6.64	1.30	9.65	1.39	13799.	0.61	280	28	1000
264011	6.64	1.38	10.23	1.37	13564.	0.59	520	28	1030
264031	8.59	1.01	9.97	1.28	13684.	0.51	60	28	1100
264051	8.59	0.82	9.89	1.28	13965.	0.57	330	28	1200
264071	7.28	1.07	8.89	1.32	13975.	0.50	570	28	1230
264091	7.28	1.08	8.48	1.32	13978.	0.45	530	28	1300
264111	10.39	1.30	9.32	1.37	13744.	0.54	500	28	1330
264131	10.39	1.72	9.46	1.39	13899.	0.57	590	28	1400
264151	9.12	0.78	8.61	1.37	13932.	0.51	590	28	1430
264171	9.12	0.75	8.64	1.39	13932.	0.46	510	28	1500
264191	8.60	0.78	8.56	1.28	14071.	0.53	480	29	800
264211	8.60	0.78	8.40	1.35	14033.	0.55	560	29	830
264231	9.24	0.78	8.45	1.22	13980.	0.61	540	29	900
264251	9.24	0.61	8.74	1.25	13948.	0.51	570	29	930
264271	8.00	0.54	8.75	1.32	14007.	0.58	500	29	1000
264291	8.00	0.54	8.75	1.39	14019.	0.42	550	29	1030
264311	7.44	1.04	9.34	1.41	13810.	0.40	600	29	1100
264331	7.44	0.97	9.01	1.37	13900.	0.57	500	29	1130
264351	6.50	0.71	9.43	1.46	13929.	0.66	500	29	1200
264371	6.50	0.77	9.02	1.46	14047.	0.50	500	29	1230
264391	9.42	0.79	9.00	1.31	13952.	0.51	360	29	1300
264411	9.42	0.84	8.94	1.37	13996.	0.58	450	29	1400
264431	7.83	0.44	8.19	1.23	14101.	0.53	360	29	1430
264451	7.83	0.58	8.27	1.25	14076.	0.51	360	29	1400
264471	9.50	1.24	8.98	1.32	13946.	0.51	360	29	1430
264491	9.50	1.25	9.04	1.19	13808.	0.51	360	29	1400
264511	7.68	0.60	8.88	1.42	13530.	0.61	360	29	1430
264531	7.68	0.32	8.90	1.32	13530.	0.61	360	29	1400
264551	5.74	0.31	9.46	1.35	13934.	0.58	360	29	1430
264571	5.74	0.41	9.20	1.23	13789.	0.51	360	29	1400
264591	9.65	0.41	8.53	1.23	13938.	0.51	360	29	1430
264611	9.65	0.46	8.50	1.12	13867.	0.58	360	29	1400
264631	7.26	0.43	8.37	1.14	14015.	0.42	360	29	1430
264651	7.26	0.21	8.31	1.13	13945.	0.42	360	29	1400
264671	9.22	0.88	8.90	1.18	13771.	0.40	360	29	1430
264691	9.22	0.40	8.98	1.15	13894.	0.51	360	29	1400
264711	8.02	0.51	8.90	1.19	13834.	0.57	360	29	1430
264731	8.02	0.22	8.84	1.20	13937.	0.58	360	29	1400
264751	8.02	0.22	9.68	1.41	13834.	0.55	360	29	1430
264771	6.92	0.14	9.17	1.30	13834.	0.50	360	29	1400
264791	6.92	0.05	9.51	1.12	13869.	0.50	360	29	1430
264811	6.48	0.36	9.16	1.12	13869.	0.50	360	29	1400
264831	6.48	0.40	9.85	1.41	13844.	0.72	360	29	1430
264851	6.68	0.37	9.76	1.46	13794.	0.51	360	29	1400
264871	5.75	0.10	9.41	1.25	13878.	0.51	360	29	1430
264891	5.75	0.17	9.97	1.23	13917.	0.58	360	29	1400
264911	6.20	0.89	10.07	1.44	13678.	0.66	360	29	1430
264931	6.20	0.94	10.07	1.44	13734.	0.63	360	29	1400
264951	7.70	0.13	9.51	1.28	13946.	0.65	360	29	1430
264971	7.70	0.10	9.63	1.21	14000.	0.65	360	29	1400

A.6 REPUBLIC STEEL CORPORATION - HOURLY AND HALF-HOUR INCREMENTAL DATA, CLEAN COAL (Cont.)

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	TONS/HR	DATE	TIME
274151	0.00	0.00	0.00	0.00	0.	0.00	0	29	1500
284011	5.22	0.65	11.01	1.53	13601.	0.66	10	30	800
284021	6.23	0.71	10.93	1.37	13553.	0.69	330	30	830
284031	6.23	0.40	10.96	1.41	13515.	0.64	500	30	900
284041	8.59	0.51	8.91	1.25	13937.	0.48	510	30	930
284051	6.77	0.62	8.75	1.19	13817.	0.50	510	30	1000
284061	5.63	0.55	8.91	1.30	13972.	0.59	510	30	1030
284071	9.32	0.52	9.42	1.37	13772.	0.58	510	30	1100
284081	5.63	0.48	8.95	1.27	14020.	0.62	510	30	1130
284091	9.32	2.10	8.96	1.35	13965.	0.60	510	30	1200
284101	9.32	1.65	8.91	1.24	13528.	0.50	520	30	1230
284111	6.01	0.47	9.36	1.19	13528.	0.47	530	30	1300
284121	6.01	0.48	9.46	1.28	13928.	0.54	530	30	1330
284131	5.71	0.41	9.72	1.25	13843.	0.53	500	30	1400
284141	5.71	0.41	9.68	1.32	13904.	0.52	540	30	1430
284151	6.04	0.66	10.50	1.33	13877.	0.60	0	30	1500
284161	5.48	0.72	9.96	1.42	13517.	0.70	0	30	1530
284171	5.48	0.66	9.62	1.32	13664.	0.62	430	30	1600
284181	5.54	0.50	9.23	1.26	13904.	0.52	520	30	1630
284191	5.45	0.70	10.25	1.25	13972.	0.54	520	30	1700
284201	5.45	0.66	10.32	1.32	13741.	0.61	530	30	1730
284211	5.45	1.10	8.12	1.32	13708.	0.64	530	30	1800
284221	5.45	1.11	8.73	1.33	14051.	0.47	530	30	1830
284231	5.86	0.95	9.16	1.33	14018.	0.43	540	30	1900
284241	5.82	0.97	8.99	1.30	13928.	0.52	0	30	1930
284251	5.82	0.63	8.81	1.28	13973.	0.47	0	30	2000
284261	7.06	0.69	8.71	1.20	14018.	0.48	0	30	2030
284271	7.06	0.79	10.08	1.42	14019.	0.53	0	30	2100
284281	5.61	0.76	9.59	1.37	13182.	0.61	50	30	2130
284291	5.61	0.79	9.87	1.30	13805.	0.50	300	31	800
284301	7.35	0.79	9.99	1.32	13804.	0.43	400	31	830
284311	6.11	0.91	9.11	1.30	13870.	0.60	400	31	900
284321	6.11	0.72	9.35	1.33	13876.	0.57	400	31	930
284331	7.22	0.80	9.36	1.28	13806.	0.57	400	31	1000
284341	7.22	0.86	9.32	1.25	13859.	0.57	400	31	1030
284351	4.43	0.91	9.17	1.19	13835.	0.63	570	31	1100
284361	6.56	0.52	9.08	1.27	13835.	0.57	570	31	1130
284371	6.56	0.54	9.67	1.18	14009.	0.55	520	31	1200
284381	6.15	0.45	9.64	1.23	13900.	0.64	520	31	1230
284391	6.15	0.58	9.26	1.30	13914.	0.67	520	31	1300
284401	6.80	0.48	9.19	1.24	14072.	0.55	520	31	1330
284411	6.79	0.44	9.56	1.38	14063.	0.54	550	31	1400
284421	6.79	0.53	9.50	1.31	13934.	0.58	502	31	1430
284431	6.81	0.66	9.80	1.27	13934.	0.73	400	31	1500
284441	5.77	0.17	9.64	1.20	13934.	0.66	400	31	1530
284451	5.77	0.53	9.66	1.31	13955.	0.67	400	31	1600
284461	5.77	0.57	9.45	1.36	13946.	0.67	400	31	1630
284471	5.77	0.57	9.45	1.24	13706.	0.62	400	31	1700
284481	5.77	0.57	9.45	1.27	14041.	0.61	400	31	1730

A.6 REPUBLIC STEEL CORPORATION - HOURLY AND HALF-HOUR INCREMENTAL DATA, CLEAN COAL (Cont.)

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	TONS/HR	DATE	TIME
294121	4.29	0.39	9.54	1.27	13960.	0.79	440	31	1330
294131	4.59	0.52	9.58	1.27	13958.	0.70			
294131	6.75	0.88	9.27	1.31	13970.	0.67	490	31	1400
294141	3.71	0.34	9.94	1.43	13993.	0.70			
294151	3.71	0.86	9.95	1.38	13988.	0.65	420	31	1430
294151	4.33	0.24	10.23	1.22	13990.	0.70			
294151	4.33	0.31	10.40	1.19	13879.	0.54	370	31	1500
304011	8.61	0.29	8.80	1.42	13879.	0.55			
304011	8.61	0.72	8.80	1.42	13958.	0.61	290	1	830
304021	5.46	0.30	8.08	1.32	13976.	0.57			
304021	5.46	0.28	8.11	1.25	13998.	0.55	290	1	900
304031	20.72	7.10	6.73	1.28	13998.	0.58			
304031	20.72	7.12	6.83	1.22	13468.	0.48	0	1	930
304041	5.98	1.32	8.96	1.28	13715.	0.51			
304041	5.98	1.09	8.53	1.31	13917.	0.47	420	1	1000
304051	5.94	0.42	8.62	1.28	13649.	0.57	500	1	1030
304051	5.94	0.41	8.63	1.24	13649.	0.54			
304061	8.41	0.27	9.66	1.31	13137.	0.64	250	1	1100
304061	8.41	0.25	9.65	1.35	13138.	0.62			
304071	5.95	0.29	8.42	1.31	13810.	0.59	270	1	1130
304071	5.95	0.92	8.52	1.42	13808.	0.58			
304081	8.82	0.55	8.72	1.03	13855.	0.59	380	1	1200
304081	8.82	0.34	8.56	1.21	14036.	0.63			
304091	7.28	0.18	8.65	1.29	14062.	0.58	600	1	1230
304101	7.86	0.11	8.84	1.26	13872.	0.49			
304101	7.86	0.46	8.78	1.41	13999.	0.63	560	1	1300
304111	5.37	0.59	8.57	1.31	13952.	0.64			
304111	5.37	0.26	9.44	1.42	13861.	0.68	500	1	1330
304121	5.37	0.49	9.30	1.44	13861.	0.68			
304121	7.21	0.73	9.41	1.54	13019.	0.50	0	0	1400
304131	7.21	0.58	9.46	1.50	13224.	0.70			
304131	12.44	1.38	9.55	1.32	13487.	0.61	0	0	1430
314011	9.65	1.48	9.57	1.39	13487.	0.55			
314011	9.65	0.67	9.15	1.46	13727.	0.66	250	5	1000
314021	8.47	0.65	8.26	1.44	13937.	0.58			
314021	8.47	1.05	8.23	1.37	13958.	0.51	500	5	1030
314031	8.37	0.97	8.58	1.35	13945.	0.50			
314031	8.37	0.43	9.04	1.30	13407.	0.46	500	5	1100
314041	11.02	1.41	9.18	1.39	13221.	0.54			
314041	11.02	1.30	9.14	1.48	13763.	0.61	200	5	1130
314051	8.88	0.65	8.43	1.48	13736.	0.52			
314051	8.88	0.65	8.43	1.32	14066.	0.52	310	5	1200
314061	8.78	0.45	8.53	1.37	14067.	0.52			
314061	8.78	0.43	8.78	1.49	14024.	0.57	590	5	1230
314071	12.51	0.40	8.84	1.44	13972.	0.62			
314071	12.51	0.55	8.51	1.37	14103.	0.50	300	5	1300
314081	8.72	0.51	8.55	1.43	14015.	0.59			
314081	8.72	0.44	9.13	1.35	13956.	0.56	560	5	1330
314091	8.57	0.33	9.19	1.37	13956.	0.51			
314091	8.57	0.65	8.93	1.41	13964.	0.54	550	5	1400
314101	8.32	0.66	8.95	1.42	13944.	0.54			
314101	8.32	0.47	8.94	1.31	13942.	0.50	560	5	1430
314101	8.32	0.62	9.00	1.39	14051.	0.49			

A.6 REPUBLIC STEEL CORPORATION - HOURLY AND HALF-HOUR INCREMENTAL DATA, CLEAN COAL (Cont.)

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	TONS/HR	DATE	TIME
314111	7.45	0.19	8.72	1.29	14022.	0.57	570	5	1500
324011	7.45	0.15	8.76	1.27	14129.	0.60	600	6	830
324021	8.95	0.75	8.36	1.22	13959.	0.42	600	6	830
324021	8.95	0.78	8.37	1.22	14042.	0.41	650	6	900
324031	12.16	1.21	8.95	1.38	13812.	0.57	580	6	930
324031	12.16	1.26	8.96	1.24	13813.	0.57	580	6	930
324031	11.40	3.10	8.36	1.30	13624.	0.49	610	6	1000
324041	11.40	2.90	8.17	1.24	13625.	0.51	610	6	1000
324041	9.32	2.31	8.57	1.22	13732.	0.50	570	6	1030
324051	9.32	2.17	8.50	1.26	13575.	0.40	570	6	1030
324051	6.61	0.54	8.62	1.37	14019.	0.46	570	6	1100
324051	6.61	0.50	8.62	1.20	14062.	0.44	570	6	1100
324061	12.01	0.95	9.24	1.21	13440.	0.45	560	6	1130
324071	12.01	1.19	9.36	1.24	13441.	0.49	560	6	1130
324071	8.62	0.57	8.77	1.26	13749.	0.50	580	6	1200
324081	8.62	0.59	8.65	1.27	13749.	0.49	580	6	1200
324081	8.50	1.15	9.06	1.29	13976.	0.49	400	6	1230
324091	8.50	1.33	9.25	1.15	13933.	0.46	400	6	1230
324091	11.84	1.96	8.97	1.35	13754.	0.48	560	6	1300
324101	11.84	2.59	9.11	1.25	13762.	0.48	560	6	1300
324111	11.31	0.93	8.67	1.27	13971.	0.47	530	6	1330
324111	11.31	1.15	8.53	1.27	13972.	0.47	540	6	1400
324121	9.25	0.73	8.56	1.24	14084.	0.44	280	6	1430
324121	9.25	0.65	8.77	1.26	14085.	0.45	510	6	1500
324131	9.53	1.63	8.68	1.26	13880.	0.43	590	7	800
324131	5.35	1.61	9.21	1.29	13939.	0.49	500	7	830
324141	5.35	0.54	8.71	1.20	13938.	0.47	580	7	900
324141	5.70	0.51	8.61	1.36	14131.	0.60	600	7	930
334011	5.70	1.32	8.78	1.10	13982.	0.44	520	7	1000
334011	4.92	1.28	8.27	1.10	14061.	0.45	400	7	1030
334021	4.92	0.77	8.51	1.24	13865.	0.40	340	7	1100
334021	7.09	0.68	8.14	1.14	13864.	0.44	500	7	1130
334031	7.09	0.70	9.11	1.20	13919.	0.42	580	7	1200
334031	7.32	0.83	8.86	1.14	13918.	0.47	400	7	1230
334041	7.32	0.67	8.77	1.26	13897.	0.53	550	7	1300
334041	6.79	0.73	8.77	1.26	13699.	0.51	200	7	1330
334051	6.79	0.63	8.80	1.16	14001.	0.45	500	7	1330
334051	6.52	0.47	9.44	1.16	14002.	0.40	520	7	1000
334051	6.52	0.49	9.15	1.24	14002.	0.40	400	7	1030
334061	5.38	0.42	9.21	1.20	13956.	0.51	340	7	1100
334071	5.38	0.38	8.97	1.22	14000.	0.51	560	7	1130
334071	6.27	0.47	8.95	1.19	14006.	0.50	270	7	1200
334081	6.27	0.39	10.55	1.20	13878.	0.52	400	7	1230
334081	6.71	0.49	10.40	1.16	13877.	0.49	550	7	1300
334091	6.71	0.34	8.97	1.14	14044.	0.46	200	7	1330
334091	5.80	0.37	8.92	1.18	14044.	0.47	500	7	1330
334101	5.80	0.47	9.07	1.12	13848.	0.48	550	7	1330
334111	5.83	0.41	9.20	1.10	13999.	0.47	550	7	1330
334111	5.83	0.39	9.23	1.28	13968.	0.47	550	7	1330
334121	5.83	0.42	9.22	1.20	13965.	0.53	200	7	1330
334121	5.83	0.41	8.75	1.24	13977.	0.43	500	7	1330
334121	5.83	0.44	9.30	1.30	13977.	0.52	200	7	1330
334121	6.62	0.33	9.28	1.30	13931.	0.50	500	7	1330
334121	6.62	0.35	9.28	1.30	13868.	0.50	500	7	1330

A.6 REPUBLIC STEEL CORPORATION - HOURLY AND HALF-HOUR INCREMENTAL DATA, CLEAN COAL, (Cont.)

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	TONS/HR	DATE	TIME
334131	5.76	0.20	9.98	1.32	13819.	0.73	520	7	1400
334141	5.76	0.42	9.94	1.36	13846.	0.58			
334151	5.15	0.59	9.72	1.25	13531.	0.45	520	7	1430
334151	6.39	0.26	9.08	1.17	13772.	0.43			
344011	6.27	0.18	8.69	1.27	14002.	0.51	410	7	1500
344021	6.27	0.30	8.48	1.31	13856.	0.53	520	8	830
344031	5.86	1.86	8.54	1.27	13839.	0.36	520	8	900
344041	5.86	1.88	8.83	1.37	13880.	0.56	520	8	900
344051	6.15	1.91	8.83	1.40	13879.	0.51	500	8	930
344061	6.15	1.39	8.95	1.33	13820.	0.47	300	8	1000
344071	5.03	1.16	9.09	1.31	13819.	0.43	520	8	1030
344081	5.03	0.47	8.73	1.32	13535.	0.46			
344091	7.18	0.67	9.13	1.31	13481.	0.52	400	8	1300
344101	7.18	2.23	9.10	1.30	13609.	0.45			
344111	5.89	1.50	9.07	1.34	13609.	0.50	420	8	1100
344121	5.89	1.04	9.86	1.18	13546.	0.47	510	8	1130
344131	5.29	0.92	9.64	1.25	13546.	0.47	500	8	1200
344141	6.86	1.52	9.09	1.20	13739.	0.43			
344151	6.86	1.67	8.88	1.21	13739.	0.48	500	8	1230
344161	6.86	1.86	8.81	1.17	13548.	0.48			
344171	5.85	2.32	8.81	1.09	13645.	0.47	500	8	1300
344181	5.85	1.34	9.56	1.31	13638.	0.55			
344191	6.90	1.29	9.04	1.26	13691.	0.41	400	8	1300
344201	6.90	1.59	9.00	1.21	13782.	0.46	520	8	1330
344211	4.74	1.63	9.12	1.10	13782.	0.48	310	8	1400
344221	4.74	0.65	9.16	1.24	13804.	0.45	170	11	800
344231	9.24	0.65	8.56	1.19	13829.	0.66	540	11	1100
344241	9.24	2.03	8.56	1.24	13700.	0.66	300	11	1200
344251	4.25	1.70	8.61	1.24	13840.	0.58			
344261	4.25	0.97	9.67	1.24	13678.	0.55	100	11	800
344271	8.77	1.22	9.41	1.32	13774.	0.57	540	11	1100
344281	8.77	0.46	8.94	1.24	13895.	0.61	300	11	1200
344291	6.63	0.46	9.11	1.33	13825.	0.64	300	11	1300
344301	6.63	4.23	9.31	1.42	13130.	0.66	450	11	1400
344311	5.62	4.00	9.59	1.53	13219.	0.56	200	11	1500
344321	5.62	0.28	11.30	1.32	13558.	0.53	160	12	800
344331	6.07	0.52	11.33	1.42	13652.	0.50	480	12	1000
344341	6.07	0.37	12.05	1.38	13514.	0.43	500	12	1100
344351	10.28	0.45	11.49	1.38	13358.	0.50	500	12	1200
344361	10.28	0.21	10.27	1.40	13400.	0.47	400	12	1300
344371	5.07	0.48	10.28	1.22	13390.	0.57			
344381	5.07	1.05	9.60	1.31	13776.	0.56	200	11	1500
344391	5.07	0.82	8.99	1.42	13776.	0.53	160	12	800
344401	5.15	1.73	10.09	1.20	13719.	0.44	480	12	1000
344411	5.23	1.34	10.25	1.29	13662.	0.50	500	12	1100
344421	5.23	1.41	10.10	1.18	13715.	0.43	500	12	1200
344431	6.68	1.45	10.06	1.20	13797.	0.48	400	12	1300
344441	6.68	1.66	9.98	1.34	13615.	0.50			
344451	6.63	1.36	10.01	1.37	13716.	0.47			
344461	6.63	1.36	10.21	1.31	13825.	0.48			
344471	4.34	0.72	11.97	1.30	14045.	0.57			
344481	4.34	0.58	11.48	1.32	14033.	0.60			

A.6 REPUBLIC STEEL CORPORATION - HOURLY AND HALF-HOUR INCREMENTAL DATA, CLEAN COAL (Cont.)

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	TONS/HR	DATE	TIME
364131	4.65	0.59	9.45	1.24	13832.	0.50	400	12	1400
364151	4.65	0.57	9.41	1.22	13872.	0.56			
364151	6.38	1.42	9.39	1.07	13871.	0.42	410	12	1500
374011	4.92	0.73	7.51	1.13	13879.	0.41	300	13	820
374031	4.92	0.68	7.65	1.04	14273.	0.46			
374031	7.02	0.63	9.03	1.06	14240.	0.43	520	13	900
374051	7.02	0.80	9.15	1.22	13884.	0.57			
374051	5.88	0.62	9.17	1.20	13970.	0.58	510	13	1000
374071	4.85	0.62	9.43	1.15	13958.	0.52			
374071	4.85	0.59	9.23	1.22	13922.	0.51	450	13	1100
374091	6.65	0.53	9.22	1.22	13978.	0.52			
374091	6.65	0.77	10.04	1.24	13978.	0.56	460	13	1200
374111	4.37	0.64	9.50	1.23	13993.	0.49	260	13	1300
374131	5.10	0.63	9.56	1.13	13949.	0.53	480	13	1400
374151	4.52	0.70	9.75	1.19	13949.	0.52			
374151	4.52	0.71	9.54	1.22	13717.	0.53	400	13	1500
384011	4.87	0.76	9.52	1.26	13940.	0.62	400	13	1500
384031	6.83	0.84	8.61	1.32	13941.	0.64	430	14	800
384051	7.42	0.81	9.07	1.11	14008.	0.45	530	14	900
384071	6.43	0.78	9.21	1.31	13866.	0.58			
384091	6.43	0.81	9.10	1.34	13988.	0.64	510	14	1000
384111	6.63	0.75	9.23	1.21	13819.	0.61	520	14	1100
384131	6.63	0.84	8.97	1.21	13991.	0.62	480	14	1200
384151	7.17	0.97	8.94	1.21	13991.	0.59			
384151	5.26	1.03	8.82	1.21	13991.	0.59	400	14	1300
384151	5.26	1.35	9.06	1.42	13834.	0.76	480	14	1400
384151	11.57	4.40	9.99	1.38	13847.	0.69	480	14	1500
384151	11.57	4.67	9.24	1.38	13880.	0.72	450	14	1600
384151	9.40	3.25	8.70	1.38	14038.	0.60	420	14	1700
384151	9.40	3.25	8.71	1.22	14038.	0.61	400	14	1800
384151	7.17	0.97	8.75	1.25	14069.	0.62	400	14	1900
384151	5.26	1.03	8.82	1.25	13964.	0.63	330	15	800
384151	5.26	1.50	9.06	1.28	13964.	0.63	500	15	900
384151	11.57	4.40	7.59	1.06	13862.	0.47	510	15	1000
384151	11.57	4.67	7.62	1.12	14016.	0.45	400	15	1100
384151	9.40	3.25	8.49	1.34	13547.	0.54	450	15	1200
384151	9.40	3.25	8.49	1.27	13309.	0.53	460	15	1300
384151	5.21	1.71	8.90	1.23	13477.	0.48	480	15	1400
384151	5.21	1.60	8.90	1.23	13477.	0.52	400	15	1500
384151	5.21	1.17	8.66	1.21	13748.	0.44	450	15	1600
384151	5.21	1.17	8.75	1.14	13748.	0.42	400	15	1700
384151	7.59	0.88	9.25	1.24	13743.	0.50	460	15	1800
384151	7.59	0.88	9.11	1.21	13743.	0.51	480	15	1900
384151	7.59	2.16	8.80	1.29	13585.	0.52	450	15	2000
384151	7.59	2.16	8.96	1.30	13751.	0.51	400	15	2100
384151	6.99	1.48	8.31	1.26	13752.	0.53	450	15	2200
384151	6.99	1.48	9.24	1.24	13677.	0.45	400	15	2300
384151	6.99	1.56	9.24	1.20	13677.	0.43	400	15	2400

STOP

END OF EXECUTION
CPU TIME: 4.56 ELAPSED TIME: 24:8.78
EXIT

A-7 REPUBLIC STEEL CORPORATION - DAILY, WEEKLY, AND MONTHLY COMPOSITE DATA

ROM COAL

CLEAN COAL

SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR	SAMPLE CODE	TOTAL MOISTURE	RESIDUAL MOISTURE	ASH	TOTAL SULFUR	BTU/LB	PYRITIC SULFUR
213171	5.61	1.16	24.51	2.35	11315.	1.23	214171	8.64	1.33	9.93	1.30	13747.	0.67
223171	8.81	0.94	24.49	2.40	11290.	1.29	224171	8.27	0.97	10.42	1.34	13729.	0.62
233171	8.81	0.32	28.10	2.47	10815.	1.53	234171	8.27	0.12	9.88	1.34	13798.	0.65
243171	7.23	0.47	27.94	2.56	10817.	1.49	244171	5.52	0.53	11.10	1.35	13945.	0.67
253171	4.43	0.46	28.32	2.65	10637.	1.53	254171	5.52	0.63	10.61	1.32	13683.	0.59
263171	4.75	0.97	28.44	2.61	10635.	1.57	264171	7.95	0.34	8.74	1.29	13636.	0.66
273171	4.43	0.91	28.88	2.81	10593.	1.76	274171	7.95	0.34	8.74	1.28	14069.	0.53
283171	4.75	0.77	30.66	2.50	10887.	1.86	284171	7.95	0.34	8.74	1.28	13887.	0.53
293171	4.75	0.67	35.91	2.50	9461.	1.55	294171	7.95	0.34	8.74	1.28	13887.	0.53
303171	4.75	0.48	28.18	2.85	10613.	1.55	304171	7.95	0.34	8.74	1.28	13887.	0.53
313171	4.16	0.56	28.78	2.87	10658.	1.86	314171	8.51	0.67	8.47	1.36	13201.	0.57
323171	0.00	0.00	0.00	0.00	0.00	0.00	324171	8.51	0.67	8.47	1.21	14007.	0.48
333171	0.00	0.00	0.00	0.00	0.00	0.00	334171	8.51	0.67	8.47	1.22	14082.	0.47
343171	4.72	0.42	28.33	2.71	10550.	1.65	344171	8.51	0.67	8.47	1.22	14115.	0.47
353171	4.72	0.45	28.94	2.74	10574.	1.71	354171	6.35	0.70	9.13	1.23	13995.	0.58
363171	4.05	0.74	32.19	2.66	10854.	1.44	364171	6.35	0.82	9.23	1.25	13713.	0.51
373171	4.05	0.71	32.11	2.44	9885.	1.37	374171	5.87	0.49	10.42	1.43	13549.	0.74
383171	4.25	0.46	26.43	2.87	10472.	1.86	384171	5.87	0.37	9.71	1.27	13549.	0.74
393171	4.25	0.40	26.08	3.17	10471.	1.67	394171	5.87	0.37	9.71	1.27	13549.	0.74
02151	4.54	0.39	28.64	3.13	10418.	1.83	02251	9.48	0.40	9.04	1.31	13626.	0.55
02251	4.54	0.26	29.21	3.06	10417.	1.94	02351	8.73	0.63	8.93	1.26	13626.	0.55
02351	3.84	0.67	36.15	2.63	10453.	1.68	02451	8.73	0.63	8.93	1.24	14180.	0.54
02451	3.84	0.63	36.04	2.61	10453.	1.45	02551	8.90	1.03	8.72	1.24	14087.	0.54
02551	5.00	0.79	31.17	2.32	10220.	1.45	02651	8.90	1.03	8.72	1.24	14016.	0.46
02651	4.48	0.81	31.15	2.35	10224.	1.60	02751	6.40	0.41	8.61	1.09	13913.	0.46
02751	4.48	0.90	36.70	2.35	9281.	1.51	02851	6.40	0.41	8.61	1.09	13913.	0.46
02851	4.48	0.90	36.84	2.38	9279.	1.58	02951	5.78	0.22	8.59	1.19	13982.	0.43
02951	4.91	0.41	25.72	2.47	11058.	1.58	03051	5.78	0.22	8.59	1.19	13982.	0.43
03051	4.91	0.37	25.78	2.37	10967.	1.32	03151	12.20	0.95	9.17	1.12	13864.	0.54
03151	6.01	0.89	31.98	2.38	10967.	1.28	03251	12.20	0.95	9.17	1.12	13864.	0.54
03251	6.01	0.92	32.36	2.32	9112.	1.47	03351	5.35	1.09	9.88	1.44	13694.	0.58
03351	5.35	0.83	31.67	2.32	10144.	1.36	03451	5.35	1.09	9.88	1.38	13867.	0.58
03451	5.35	0.80	31.06	2.27	9826.	1.43	03551	4.82	0.73	9.15	1.35	13862.	0.56
03551	4.45	0.58	26.80	2.30	10752.	1.27	03651	4.82	0.70	9.20	1.22	13577.	0.59
03651	4.45	0.62	27.25	2.39	10752.	1.58	03751	6.57	1.10	9.20	1.25	13577.	0.59
03751	4.45	0.62	27.25	2.39	10752.	1.58	03851	6.57	1.10	9.20	1.25	13577.	0.59
03851	5.93	1.88	30.21	2.55	10137.	1.60	03951	7.70	0.90	9.35	1.27	13734.	0.64
03951	5.93	1.83	30.26	2.54	10065.	1.62	04051	7.70	1.20	8.56	1.28	13946.	0.53
04051	4.88	0.66	32.96	2.41	9820.	1.66	04151	7.70	1.16	9.05	1.26	13832.	0.62
04151	4.88	0.72	33.22	2.46	9762.	1.66	04251	7.26	1.38	9.41	1.42	13952.	0.67
04251	4.46	0.57	31.52	3.27	10080.	1.75	04351	7.26	1.26	9.63	1.47	13657.	0.69
04351	4.46	0.79	31.47	3.19	9835.	2.17	04451	7.17	0.45	9.18	1.47	14058.	0.56
04451	4.40	1.56	28.53	2.77	10389.	2.08	04551	6.55	0.48	8.72	1.25	14000.	0.54
04551	4.40	1.49	28.52	2.81	10383.	1.63	04651	6.55	0.48	8.72	1.25	14000.	0.54
04651	4.70	1.15	29.37	2.66	10399.	1.66	04751	7.30	0.52	8.84	1.14	13931.	0.44
04751	4.70	1.20	29.89	2.61	10374.	1.44	04851	7.30	1.62	9.39	1.32	13722.	0.53
04851	4.96	0.84	29.58	2.89	10482.	1.60	04951	6.91	1.31	8.58	1.13	13946.	0.51
04951	4.96	0.76	29.26	2.85	10510.	1.71	05051	6.91	1.22	8.53	1.20	13930.	0.49

TABLE A-8. R&F Coal Company - DATA FOR RAW COAL BY STOCKPILE

SAMPLE NO.	ASH	PARTIC SURFAC	ORGANIC SURFAC	TOTAL SURFAC	BTU-LB	MOISTURE	EMISSIONS	Stockpiles
1145	2.48	2.11	0.53	3.03	1080	5.73	5.63	Stockpiles 8, 9, 11
1147	2.23	2.44	0.53	3.68	1054	5.42	5.20	
1148	1.97	1.72	1.36	3.07	1209	5.28	5.47	
1149	1.80	1.64	1.11	2.75	1177	5.64	5.70	
1150	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1151	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1152	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1153	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1154	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1155	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1156	1.41	2.06	1.13	3.19	1059	5.53	5.11	Stockpiles 8, 9, 11
1157	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1158	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1159	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1160	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1161	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1162	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1163	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1164	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1165	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1166	1.41	2.06	1.13	3.19	1059	5.53	5.11	Stockpiles 8, 9, 11
1167	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1168	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1169	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1170	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1171	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1172	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1173	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1174	1.41	2.06	1.13	3.19	1059	5.53	5.11	
1175	1.41	2.06	1.13	3.19	1059	5.53	5.11	

This set continued in next column.

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FIGURE A-9. R&F COAL COMPANY - DATA FOR CLEAN COAL FROM DISCRETE STOCKPILES

SAMPLE NO.	ASH	PHOSPHORIC SULFUR	ORGANIC SULFUR	TOTAL SULFUR	BTU/LB	MOISTURE	EMISSIONS
1	1.30	1.45	1.65	3.40	1234	4.27	3.77
2	1.30	1.45	1.65	3.40	1234	4.27	3.77
3	1.30	1.45	1.65	3.40	1234	4.27	3.77
4	1.30	1.45	1.65	3.40	1234	4.27	3.77
5	1.30	1.45	1.65	3.40	1234	4.27	3.77
6	1.30	1.45	1.65	3.40	1234	4.27	3.77
7	1.30	1.45	1.65	3.40	1234	4.27	3.77
8	1.30	1.45	1.65	3.40	1234	4.27	3.77
9	1.30	1.45	1.65	3.40	1234	4.27	3.77
10	1.30	1.45	1.65	3.40	1234	4.27	3.77
11	1.30	1.45	1.65	3.40	1234	4.27	3.77
12	1.30	1.45	1.65	3.40	1234	4.27	3.77
13	1.30	1.45	1.65	3.40	1234	4.27	3.77
14	1.30	1.45	1.65	3.40	1234	4.27	3.77
15	1.30	1.45	1.65	3.40	1234	4.27	3.77
16	1.30	1.45	1.65	3.40	1234	4.27	3.77
17	1.30	1.45	1.65	3.40	1234	4.27	3.77
18	1.30	1.45	1.65	3.40	1234	4.27	3.77
19	1.30	1.45	1.65	3.40	1234	4.27	3.77
20	1.30	1.45	1.65	3.40	1234	4.27	3.77
21	1.30	1.45	1.65	3.40	1234	4.27	3.77
22	1.30	1.45	1.65	3.40	1234	4.27	3.77
23	1.30	1.45	1.65	3.40	1234	4.27	3.77
24	1.30	1.45	1.65	3.40	1234	4.27	3.77
25	1.30	1.45	1.65	3.40	1234	4.27	3.77
26	1.30	1.45	1.65	3.40	1234	4.27	3.77
27	1.30	1.45	1.65	3.40	1234	4.27	3.77
28	1.30	1.45	1.65	3.40	1234	4.27	3.77
29	1.30	1.45	1.65	3.40	1234	4.27	3.77
30	1.30	1.45	1.65	3.40	1234	4.27	3.77
31	1.30	1.45	1.65	3.40	1234	4.27	3.77
32	1.30	1.45	1.65	3.40	1234	4.27	3.77
33	1.30	1.45	1.65	3.40	1234	4.27	3.77
34	1.30	1.45	1.65	3.40	1234	4.27	3.77
35	1.30	1.45	1.65	3.40	1234	4.27	3.77
36	1.30	1.45	1.65	3.40	1234	4.27	3.77
37	1.30	1.45	1.65	3.40	1234	4.27	3.77
38	1.30	1.45	1.65	3.40	1234	4.27	3.77
39	1.30	1.45	1.65	3.40	1234	4.27	3.77
40	1.30	1.45	1.65	3.40	1234	4.27	3.77
41	1.30	1.45	1.65	3.40	1234	4.27	3.77
42	1.30	1.45	1.65	3.40	1234	4.27	3.77
43	1.30	1.45	1.65	3.40	1234	4.27	3.77
44	1.30	1.45	1.65	3.40	1234	4.27	3.77
45	1.30	1.45	1.65	3.40	1234	4.27	3.77
46	1.30	1.45	1.65	3.40	1234	4.27	3.77
47	1.30	1.45	1.65	3.40	1234	4.27	3.77
48	1.30	1.45	1.65	3.40	1234	4.27	3.77
49	1.30	1.45	1.65	3.40	1234	4.27	3.77
50	1.30	1.45	1.65	3.40	1234	4.27	3.77
51	1.30	1.45	1.65	3.40	1234	4.27	3.77
52	1.30	1.45	1.65	3.40	1234	4.27	3.77
53	1.30	1.45	1.65	3.40	1234	4.27	3.77
54	1.30	1.45	1.65	3.40	1234	4.27	3.77
55	1.30	1.45	1.65	3.40	1234	4.27	3.77
56	1.30	1.45	1.65	3.40	1234	4.27	3.77
57	1.30	1.45	1.65	3.40	1234	4.27	3.77
58	1.30	1.45	1.65	3.40	1234	4.27	3.77
59	1.30	1.45	1.65	3.40	1234	4.27	3.77
60	1.30	1.45	1.65	3.40	1234	4.27	3.77
61	1.30	1.45	1.65	3.40	1234	4.27	3.77
62	1.30	1.45	1.65	3.40	1234	4.27	3.77
63	1.30	1.45	1.65	3.40	1234	4.27	3.77
64	1.30	1.45	1.65	3.40	1234	4.27	3.77
65	1.30	1.45	1.65	3.40	1234	4.27	3.77
66	1.30	1.45	1.65	3.40	1234	4.27	3.77
67	1.30	1.45	1.65	3.40	1234	4.27	3.77
68	1.30	1.45	1.65	3.40	1234	4.27	3.77
69	1.30	1.45	1.65	3.40	1234	4.27	3.77
70	1.30	1.45	1.65	3.40	1234	4.27	3.77
71	1.30	1.45	1.65	3.40	1234	4.27	3.77
72	1.30	1.45	1.65	3.40	1234	4.27	3.77
73	1.30	1.45	1.65	3.40	1234	4.27	3.77
74	1.30	1.45	1.65	3.40	1234	4.27	3.77
75	1.30	1.45	1.65	3.40	1234	4.27	3.77
76	1.30	1.45	1.65	3.40	1234	4.27	3.77
77	1.30	1.45	1.65	3.40	1234	4.27	3.77
78	1.30	1.45	1.65	3.40	1234	4.27	3.77
79	1.30	1.45	1.65	3.40	1234	4.27	3.77
80	1.30	1.45	1.65	3.40	1234	4.27	3.77
81	1.30	1.45	1.65	3.40	1234	4.27	3.77
82	1.30	1.45	1.65	3.40	1234	4.27	3.77
83	1.30	1.45	1.65	3.40	1234	4.27	3.77
84	1.30	1.45	1.65	3.40	1234	4.27	3.77
85	1.30	1.45	1.65	3.40	1234	4.27	3.77
86	1.30	1.45	1.65	3.40	1234	4.27	3.77
87	1.30	1.45	1.65	3.40	1234	4.27	3.77
88	1.30	1.45	1.65	3.40	1234	4.27	3.77
89	1.30	1.45	1.65	3.40	1234	4.27	3.77
90	1.30	1.45	1.65	3.40	1234	4.27	3.77
91	1.30	1.45	1.65	3.40	1234	4.27	3.77
92	1.30	1.45	1.65	3.40	1234	4.27	3.77
93	1.30	1.45	1.65	3.40	1234	4.27	3.77
94	1.30	1.45	1.65	3.40	1234	4.27	3.77
95	1.30	1.45	1.65	3.40	1234	4.27	3.77
96	1.30	1.45	1.65	3.40	1234	4.27	3.77
97	1.30	1.45	1.65	3.40	1234	4.27	3.77
98	1.30	1.45	1.65	3.40	1234	4.27	3.77
99	1.30	1.45	1.65	3.40	1234	4.27	3.77
100	1.30	1.45	1.65	3.40	1234	4.27	3.77

This set continued in next column.

APPENDIX B
COAL TESTING PROCEDURES

- B.1 Determination of Total Sulfur in Coal
- B.2 Standard Test Method for Pyritic Sulfur in Coal
- B.3 Standard Test Method for Gross Calorific Value (Btu)
- B.4 Standard Test Method for Ash in the Analysis of Coal
- B.5 Standard Test Method for Air-Dry Loss and Residual Moisture in Coal
- B.6 Total Moisture Determination

APPENDIX B

COAL TESTING PROCEDURES

B.1 DETERMINATION OF TOTAL SULFUR IN COAL (High Frequency Combustion Titration Procedure)

Summary of Method

Total sulfur is determined by combusting a weighed sample of coal at a high temperature in a stream of oxygen. The sulfur oxides formed pass into a titration vessel containing a dilute acid solution, potassium iodate, potassium iodide, and starch indicator. The sulfur dioxide reacts with the blue starch iodine complex, bleaches it, forming sulfuric acid and hydrogen iodide (HI). Potassium iodate titrant is added automatically until all the sulfur dioxide has been titrated. The amount of standard iodate consumed during the combustion is a direct measure of the sulfur content of the sample.

National Bureau of Standards reference samples for sulfur in coal and other commercially available certified standards are used to calibrate the system on a daily basis.

Apparatus

- Leco high frequency induction furnace
- Automatic sulfur titrator
- Oxygen purifying train
- Analytical balance, sensitive to 0.1 mg

Reagents and Materials

- Hydrochloric acid (15 + 985)
- Potassium iodate (0.444 g/l)

- Arrowroot starch solution (29/200 ml)
+ 6 g potassium iodide
- Deionized water, reagent grade
- Iron powder accelerator
- Vanadium Pentoxide accelerator
- Oxygen
- Coal standards - National Bureau of Standards
1.62% (± 0.03) % sulfur
- Combustion crucibles + porous covers

Procedure

- Weight 0.1 g of analysis sample into a preweighed combustion crucible containing one large scoop (LECO) of vanadium pentoxide. Cover the sample with two small scoops of iron powder followed by another large scoop of vanadium pentoxide. Place a porous ceramic cover on the crucible.
- Fill the buret with potassium iodate solution. Add dilute hydrochloric acid to the titration vessel and 5 ml of starch solution. Adjust the endpoint control to give a medium blue color.
- Preheat the combustion furnace for 5 minutes. Set the igniter timer for 6 minutes for R&F Coal, and 5 minutes for Republic Coal, and adjust the oxygen flow rate at 1.0 l/min. Place the crucible containing the sample, accelerator, and cover on the pedestal. Set the automatic titrator switch to titrate and start the igniter timer. After 1 minute, the igniter will glow red, raise the pedestal and crucible into the induction tube. Combust the sample for 5 minutes. The sulfur dioxide produced is automatically titrated to the preset endpoint. The iodate consumed is directly proportional to the sulfur content.
- Prepare reagent blanks using the same procedure but without a sample.

- Prepare and run ten replicates of a standard coal sample using the above procedure. Average the final buret readings to use in the "F" factor calculation.

Calculations

- $\% \text{ Total Sulfur} = A \times B \times F$

A = KlO_3 titrant consumed

B = Correction factor for KlO_3 solution

F = Calculated from standard coal samples

- $F = \frac{C \times D}{A \times B}$

C = % sulfur of standard

D = Sample weight (g)

A = Average KlO_3 used for the ten standard replicates

B = KlO_3 correction factor

Quality Control

The difference between duplicate analyses should not exceed (expressed at % total sulfur):

<u>Coal Type</u>	<u>Concentration Range</u>	<u>RC (Control Range)</u>
Clean	3 - 4	0.24
Raw	0 - 3	0.16
	3 - 4.5	0.19

B.2 STANDARD TEST METHOD FOR PYRITIC SULFUR IN COAL
(ASTM D-2492)

Summary of Method

Pyritic sulfur is determined by extracting a weighed sample of coal with dilute nitric acid followed by atomic absorption determination of iron in the extract as a measure of pyritic sulfur. Extraction of pyritic sulfur from coal with dilute nitric acid involves oxidation of ferrous iron to ferric and sulfide sulfur to sulfate, both of which are soluble in nitric acid. Because the extraction dissolves sulfate and pyritic sulfur plus a small amount of organic sulfur, the dissolved sulfur is not a reliable measure of pyritic sulfur. Consequently, sulfate sulfur must be removed first, through a hydrochloric acid digestion, before the sample can be digested with nitric acid for pyritic sulfur.

Apparatus

- Balance, sensitive to 1 mg
- Hot plate
- Atomic Absorption Spectrophotometer

Reagents and Materials

- Hydrochloric Acid (2 + 3), ACS grade
- Nitric Acid (1 + 7), ACS grade
- Deionized Water, reagent grade
- Filters, glass fiber with suitable holder
- Flasks, 250 ml Erlenmeyer

Procedure

- Extraction of Pyritic Sulfur - Weigh to the nearest 0.1 mg about 5 grams of sieved sample (60 mesh) and transfer to a 250 ml flask. Add 50 ml of dilute HCl and boil for 30 minutes. Filter the residue through a glass fiber filter and discard the filtrate containing the soluble sulfates. Transfer the residue and filter to the 250 ml flask, add 50 ml HNO_3 and either boil for 30 minutes

or let stand overnight at room temperature. Cool the mixture, filter and volumetrically dilute to 250 ml. Prepare reagent blanks using the same procedure but without a sample.

- Determination of Iron by Atomic Absorption - Using a certified stock solution, iron standards are prepared to cover the expected range of iron concentrations (0-400 mg/l). A calibration curve is prepared by linear regression analysis of iron concentration versus absorbency (at the 372 nm line). Samplers and blanks are analyzed at the same instrumental conditions, and iron concentrations are calculated from the linear regression equation.

Calculation

$$\% \text{ Pyritic Sulfur} = \frac{DXV}{W} \times 114.83$$

D = iron in sample - iron in reagent blank (mg/l)

V = final volume of digested sample (liters)

W = sample weight (milligrams)

114.83 = percent atomic weight of iron in pyritic sulfur

Quality Control

The difference between duplicate analyses should not exceed (expressed at % pyritic sulfur):

<u>Coal Type</u>	<u>Concentration Range</u>	<u>RC (Control Range)</u>
Clean	0 - 2	0.17%
Raw	0 - 0.5	0.18%
	0.5 - 1.0	0.20%
	1.0 - 3.0	0.46%

B.3 STANDARD TEST METHOD FOR GROSS CALORIFIC VALUE (BTU)
(ASTM D-2015)

Summary of Method

- Calorific value is determined in this method by burning a weighed sample in an adiabatic oxygen bomb calorimeter under controlled conditions. The calorific value is computed from temperature observations made before and after combustion, making proper allowance for thermochemical corrections.

Apparatus

- Calorimeter, adiabatic jacket
- Oxygen Bomb
- Thermometer, traceable to NBS
- Sample Holder
- Programmer (optional)
- Printer (optional)

Reagents and Materials

- Deionized water, reagent grade
- Benzoic acid, NBS certified
- Methyl orange indicator solution
- Oxygen, 99.5% pure
- Sodium carbonate (7.68 g/l)
- Fuse Wire, nickel-chromium alloy, 10 cm lengths

Procedure

- Preparation of the Oxygen Bomb - weight 1 gram $\pm$ 0.1 mg of pulverized coal into a tared comb crucible. Attach the fuse wire to the oxygen bomb electrodes, insert the sample crucible, add 1 ml of water to the bomb, assemble bomb cover and charge to 30 atmospheres of oxygen.
- Oxygen Bomb Ignition - place the charged bomb in a stainless steel bucket containing 2000 $\pm$ 0.5 g of water. Connect the ignition

wires and install the bucket/bomb in the calorimeter. Initiate the 15-minute program cycle by pushing the start button. The program's first five minutes are an equilibrium period during which bucket temperatures are recorded in 30-second intervals. At the five minute mark, the bomb fires automatically. The temperature print-out is suspended for the next three minutes because temperature rises rapidly. Following this three minute wait period, temperatures are printed at 30 second intervals for the duration of the cycle. During the entire cycle, hot and cold water are added to the jacket automatically to prevent a heat exchange between the bomb and the surrounding jacket. Initial and final temperatures are read from the print-out. The initial temperature is the last recorded temperature before the bomb fires and the final temperature is the highest repeated temperature recorded within the last two minutes of the program.

- Analysis of Bomb Contents - remove the bomb and slowly release the pressure at a uniform rate. Examine the bomb interior and discard the test if unburned sample or sooty deposits are found. Wash the interior of the bomb with distilled water, dilute the washing to 150 ml, and titrate with standard sodium carbonate. Remove and measure the remaining length of fuse wire. Calculate the burnt fuse wire length from the difference between the original and the final lengths.
- Calibration - determine the water equivalent (W) of each calorimeter as the average of a series of ten individual runs of benzoic acid. Prepare a 1 gram $\pm$ 0.1 mg pellet of benzoic acid (using a die and press). Ignite and analyze the bomb contents as previously described. The standard deviation of the calculation of W should not exceed 6.5 Btu/°C.

Calculation

- Water equivalent, W - for a series of ten individual benzoic acid ignitions, calculate W using the following formula:

$$\left[W = \frac{(H) (g) + e_1 + e_3}{t} \right]$$

W = water equivalent

H = heat of combustion of benzoic acid from National Bureau of Standards Certificate (cal/g)

g = weight of benzoic acid (g)

t = temperature rise (°C)

e₁ = correction for the heat of formation of HNO₃
(ml Na₂ CO₃ x 1 cal/ml = cal)

e₃ = correction for heat of combustion of firing wire
(2.3 cal/cm)

- Gross Calorific Value, Q_v - the gross heat content, in cal/g is equal to:

$$\left[Q_v = \frac{(t) (W) - e_1 - e_2 - e_3}{g} \right]$$

Q_v = heat content (cal/g)

t = temperature rise (°C)

W = water equivalent (cal/°C)

e₁ = heat of formation of HNO₃ (cal.)

e₂ = correction for heat of formation of H₂SO₄
(% sulfur x 14 x grams sample = cal.)

e₃ = heat of combustion of firing wire (cal.)

g - sample weight (grams)

- Conversion to Btu/lb.

$$\text{cal/g} \times 1.8 = \text{Btu/lb}$$

Quality Control

The difference between duplicate analyses should not exceed (expressed as Btu/lb):

<u>Coal Type</u>	<u>Concentration Range</u>	<u>RC (Control Range)</u>
Clean	5,000 - 15,000	165
Raw	5,000 - 10,000	189
	10,000 - 20,000	217

B.4 STANDARD TEST METHOD FOR ASH IN THE ANALYSIS OF COAL
(ASTM D-3174)

Summary of Method

Ash is determined by weighing the residue remaining after burning the coal under rigidly controlled conditions of sample weight, temperature, time, and atmosphere.

Apparatus

- Balance, sensitive to 0.1 mg
- Electric muffle furnace - capable of regulated temperatures between 700° and 750°C

Reagents and Materials

- Porcelain capsules, 7/8" (22 mm) in depth, and 1 3/4" (44 mm) in diameter

Procedure

- Place the porcelain capsules containing the dried coal from the moisture determination, ASTM D-3173 (Appendix D), in a coal muffle furnace. Heat gradually so that the temperature reaches 750°C in 4 hours. Transfer the capsule to a dessicator for cooling. Weigh the dish after it has completely cooled.

Calculations

$$\left[\% \text{ Ash} = (A - B)/C \times 100 \right]$$

A = weight of capsule and ash residue (g)

B = weight of empty capsule (g)

C = weight of analysis sample before drying (g)

Quality Control

The difference between duplicate analyses should not exceed (expressed as % ash):

<u>Coal Type</u>	<u>Concentration Range</u>	<u>RC (Control Range)</u>
Clean	-	-
Raw	15 - 20	0.85%
	20 - 30	0.86%
	30 - 50	0.97%
	15 - 25	0.93%

B.5 STANDARD TEST METHOD FOR AIR-DRY LOSS AND RESIDUAL MOISTURE IN COAL
(ASTM D-3173, D-3302)

Summary of Method

- This method is based on the loss in weight of a coal sample in an air atmosphere under rigidly controlled conditions of temperature, time, and air flow.
- Final moisture determination, or residual moisture, is made in a heated forced-air circulation oven under rigidly defined conditions.
- The total moisture is calculated from losses (or gains) in air-drying and the residual moisture determinations.

Apparatus

- Drying area, clean floor or equivalent which allows good air circulation.
- Air drying oven, forced air 10 to 15°C above room temperature.
- Drying oven, forced-draft type 107 ± 3°C.
- Scale, sensitive to 20 g.
- Balance, analytical, sensitive to 0.1 mg.

Reagents and Materials

- Drying Pans, non-corroding.
- Crucibles, low profile, preconditioned at 500°C.
- Dessicator.

Procedure

- Determination of air dry moisture loss.
A gross sample of coal is spread onto a tared drying pan. The spreading should be even, with the depth not more than one-half inch, to allow for proper air drying. The gross sample is weighed and allowed to dry for 10 to 18 hours. The coal sample is re-weighed, and the weight loss of the sample is used to determine percent air-dry loss moisture.

- Determination of residual moisture.

The gross sample after air-drying is pulverized, split, and seived to pass a 60 mesh (250 μ m) screen. A 1.0 gram sample of coal is weighed into a conditioned, tared crucible. The sample is placed into a drying oven at 107°C for 45 minutes. The sample is then cooled in a dessicator for ten minutes and weighed. The percent residual moisture is calculated from the difference in the initial and final weights.

Calculations

- Air-Dry Loss (%)

$$A = \frac{L}{G} \times 100$$

A = % air dry loss

L = Loss in weight after air drying (g)

G = Weight of initial sample (g)

- Residual Moisture (%)

$$R = \left[\frac{(W - H)}{W} \times 100 \right]$$

W = Weight of initial sample (g)

H = Weight of sample after heating (g)

- Total Moisture (%)

$$M = \frac{R (100 - A)}{100} + A$$

M = % total moisture

A = % air-dry loss

R = % residual moisture

Quality Control

Difference between duplicate analyses, expressed in terms of % residual moisture, should not exceed:

<u>Coal Type</u>	<u>Concentration Range</u>	<u>RC (Control Range)</u>
Clean	0 - 6	0.56%
Raw	0 - 3	0.40%

B.6 TOTAL MOISTURE DETERMINATION
(ASTM D-2961)

Summary of Method

- This method determines total moisture directly by measuring the weight loss of a coal sample dried in an air atmosphere under rigidly controlled conditions of temperature, time, and air flow.

Apparatus

- Drying oven, forced draft type, $107 \pm 3^{\circ}\text{C}$
- Balance, analytical, sensitive to 0.1 mg.

Reagents and Materials

- Drying pans, disposable and non-corroding

Procedure

- Weigh a 100 gram sample into preconditioned tared pan. Distribute the same 38 mm (1.5 in) deep over the pan.
- Place the pan and sample in a $107 \pm 3^{\circ}\text{C}$ oven and dry sample for *1 hour. Remove from the oven and weigh.

*Sample dried and weighed in 1/4 hr increments to constant weight to establish 1 hr drying time.

Calculations

$$\text{Total moisture} = \frac{W_1 - W_2}{W_1} \times 100$$

W_1 = Weight of initial sample (g)

W_2 = Weight of dried sample (g)

APPENDIX C

SAMPLE CODES

- C.1 R&F Coal Company (Daily)
- C.2 R&F Coal Company (Incremental) - Raw Coal
- C.3 R&F Coal Company (Incremental) - Clean Coal
- C.4 R&F Coal Company (Composites)
- C.5 Republic Steel Corporation (Daily) - Raw Coal
- C.6 Republic Steel Corporation (Daily) - Clean Coal
- C.7 Republic Steel Corporation (Composites)

APPENDIX C

SAMPLE CODES

C.1 R&F COAL COMPANY - SAMPLE CODES (DAILY)

COAL SAMPLE	DAY												
	1	2	3	4	5	6	7	8	9	10	11	12	13
RAW FEED	131	231	331	431	531	631	731	831	931	1031	1131	1231	1331
	132	232	332	432	532	632	732	832	932	1032	1132	1232	1332
	133	233	333	433	533	633	733	833	933	1033	1133	1233	1333
DAILY COMPOSITE	134	234	334	434	534	634	734	834	934	1034	1134	1234	1334
CLEAN PRODUCT	141	241	341	441	541	641	741	841	941	1041	1141	1241	1341
	142	242	342	442	542	642	742	842	942	1042	1142	1242	1342
	143	243	343	443	543	643	743	843	943	1043	1143	1243	1343
DAILY COMPOSITE	144	244	344	444	544	644	744	844	944	1044	1144	1244	1344
DAY	14	15	16	17	18	19							
RAW FEED	1431	1531	1631	1731	1831	1931							
	1432	1532	1632	1732	1832	1932							
	1433	1533	1633	1733	1833	1933							
DAILY COMPOSITE	1434	1534	1634	1734	1834	1934							
CLEAN PRODUCT	1441	1541	1641	1741	1841	1941							
	1442	1542	1642	1742	1842	1942							
	1443	1543	1643	1743	1843	1943							
DAILY COMPOSITE	1444	1544	1644	1744	1844	1944							

LEGEND: SUBMITTING DAY (1, 30) 3 = RAW COAL (INTERVAL) 4 = CLEAN (INTERVAL) INTERVALS (1, 3) DAILY COMPOSITE (4)

NOTE: .1 and .2 INDICATE ANALYSIS DUPLICATES (I.e., 613.1 and 613.2)

C.2 R&F COAL COMPANY - SAMPLE (INCREMENTAL) - RAW COAL

A	DAY											
	A	A	A	A	B	B	B	B	B	B	C	C
A11	A117	A133			B11	B17	B13				C11	C17
A12	A118	A134			B12	B18	B14				C12	C18
A13	A119	A135			B13	B19	B15				C13	C19
A14	A120	A136			B14	B20	B16				C14	C20
A15	A121	A137			B15	B21	B17				C15	C21
A16	A122	A138			B16	B22	B18				C16	C22
A17	A123	A139			B17	B23	B19				C17	C23
A18	A124	A140			B18	B24	B20				C18	C24
A19	A125	A141			B19	B25	B21				C19	C25
A110	A126	A142			B110	B26	B22				C110	C26
A111	A127	A143			B111	B27	B23				C111	C27
A112	A128				B112	B28	B24				C112	C28
A113	A129				B113	B29	B25				C113	C29
A114	A130				B114	B30	B26				C114	C30
A115	A131				B115	B31	B27				C115	C31
A116	A132				B116	B32	B28				C116	C32
A31	A32	A33	A34		B31	B32	B33	B34			C31	C32
												C34

28
INTERPRETS (1, 48)
INTERPRETS (1, 3)
CONVECTIVE (4)

1
1 = RAW COAL INCREMENT
3 = RAW COAL INTERVAL

A
SAMPLING DAY
(A, B, C)

NOTE: .1 and .2 INDICATE ANALYSIS DIFFICULTIES (i.e., A128.1 and A128.2)

C.3 R&F COAL COMPANY - SAMPLE CODE (INCREMENTAL) - CLEAN COAL

A	A	A	A	A	B	B	B	B	B	B	C	C	C	C
A21	A217	A233			B21	B217	B233				C21	C217		
A22	A218	A234			B22	B218	B234				C22	C218		
A23	A219	A235			B23	B219	B235				C23	C219		
A24	A220	A236			B24	B220	B236				C24	C220		
A25	A221	A237			B25	B221	B237				C25	C221		
A26	A222	A238			B26	B222	B238				C26	C222		
A27	A223	A239			B27	B223	B239				C27	C223		
A28	A224	A240			B28	B224	B240				C28	C224		
A29	A225	A241			B29	B225	B241				C29	C225		
A210	A226	A242			B210	B226	B242				C210	C226		
A211	A227	A243			B211	B227	B243				C211	C227		
A212	A228				B212	B228	B244				C212	C228		
A213	A229				B213	B229	B245				C213	C229		
A214	A230				B214	B230	B246				C214	C230		
A215	A231				B215	B231	B247				C215	C231		
A216	A232				B216	B232	B248				C216	C232		
A41	A42	A43	A44		B41	B42	B43	B44			C41	C42	C44	

2
INCREMENTS (1,48)
INTERVALS (1,3)
CORES/PTS (4)

4
2 = CLEAN COAL, INCREMENTAL
4 = CLEAN COAL, INTERVAL

B
SAMPLING DAY
(A,B,C)

NOTE: .1 and .2 INDICATE ANALYSIS DOWNGRADES (i.e., B42.1 and B42.2)

C-5 REPUBLIC STEEL CORPORATION - SAMPLE CODES (DAILY) - RAW COAL

COAL SAMPLE	1	DAY											
		2	3	4	5	6	7	8	9	10	11	12	13
RAW FEED	21301	22301	23301	24301	25301	26301	27301	28301	29301	30301	31301	32301	33301
						26302	27302	28302	29302	30302	31302	32302	33302
	21303	22303	23303	24303	25303	26303	27303	28303	29303	30303	31303	32303	33303
						26304	27304	28304	29304	30304	31304	32304	33304
	21305	22305	23305	24305	25305	26305	27305	28305	29305	30305	31305	32305	33305
						26306	27306	28306	29306	30306	31306	32306	33306
	21307	22307	23307	24307	25307	26307	27307	28307	29307	30307	31307	32307	33307
						26308	27308	28308	29308	30308	31308	32308	33308
	21309	22309	23309	24309	25309	26309	27309	28309	29309		31309	32309	33309
						26310	27310	28310	29310		31310	32310	33310
		22311	23311		25311	26311	27311	28311	29311		31311	32311	33311
							27312	28312	29312			32312	33312
			23313		25313		27313	28313	29313			32313	33313
							27314	28314	29314			32314	33314
DAILY COMPOSITE	21317	22317	23317	24317	25317	26317	27317	28317	29317	30317	31317	32317	33317
GREENT	21			3				02					
	DAY CODE			3 = RAW	COAL			INCREMENT					
	(21, 40)												

[illegible]

C.6 REPUBLIC STEEL CORPORATION - SAMPLE CODES (DAILY) - CLEAN COAL

COAL SAMPLE	1	DAY											
		2	3	4	5	6	7	8	9	10	11	12	13
CLEAN	21401	22401	23401	24401	25401	26401	27401	28401	29401	30401	31401	32401	33401
						26402	27402	28402	29402	30402	31402	32402	33402
	21403	22403	23403	24403	25403	26403	27403	28403	29403	30403	31403	32403	33403
						26404	27404	28404	29404	30404	31404	32404	33404
		22405	23405	24405	25405	26405	27405	28405	29405	30405	31405	32405	33405
						26406	27406	28406	29406	30406	31406	32406	33406
		22407	23407	24407	25407	26407	27407	28407	29407	30407	31407	32407	33407
						26408	27408	28408	29408	30408	31408	32408	33408
	22409		23409	24409	25409	26409	27409	28409	29409	30409	31409	32409	33409
						26410	27410	28410	29410	30410	31410	32410	33410
		22411	23411	24411	25411		27411	28411	29411	30411	31411	32411	33411
							27412	28412	29412	30412		32412	33412
			23413	24413	25413		27413	28413	29413	30413		32413	33413
							27414	28414	29414			32414	33414
							27415	28415	29415				
DAILY COMPOSITE	21417	22417	23417	24417	25417	26417	27417	28417	29417	30417	31417	32417	33417
133380	21			4				02					
DAY CODE (21, 40)				4 = CLEAN COAL				INCORRECT					

	COD. SAMPLE	DAY	14	15	16	17	10	19
	CLEAN		34401 34402 34403 34404 34405 34406 34407 34408 34409 34410 34411 34412 34413	35401 35403 35405 35407 35409 	36401 36403 36405 36407 36409 36411 36413	37401 37403 37405 37407 37409 37411 37413	38401 38403 38405 38407 38409 38411 38413	39401 39403 39405 39407 39409 39411 39413
	DAILY CORRECTIVE		34417	35417	36417	37417	38417	39417

[illegible]